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Analyses of Hygienic Properties of Modified Non-Woven Nursing Pads

Monika BOGUSŁAWSKA-BĄCZEK *

Department of Textile Engineering and Science of Commodities, Institute of Textile Engineering and Polymers Materials, Faculty of Materials and Environmental Sciences, University of Bielsko-Biala, Willowa 2, 43-309 Bielsko-Biala, Poland

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The paper aims to investigate the hygienic properties of disposable non-woven nursing pads and modification with focus on their increased protection function during lactation and indications from the early breast's pathological changes. To optimise parameters of nursing pads, the area density, thickness, air permeability and resistance of the leakage have been investigated. The modification has been performed by the specially designed modifier on the interior nursing pad's surface. The thermoplastic elastomer with addition of termochromic pigment was used as modifier. The modified pads were subjected to investigation, consisting of a gradual local heating. After heating the colour changes of modifier were evaluated. The changes of the temperature corresponded with the values of skin temperature of diseased breast woman. The air permeability and the resistance of the leakage have been investigated to test the influence of modification process.

Keywords: non-woven nursing pads, hygienic properties, termochromic pigment, resistance of the leakage.

1. INTRODUCTION

The period of pregnancy and lactation is a time when women's breasts change over time. They are more sensitive, more prone to abrasion and disease. A bra with special physical properties adapted to the processes taken place in woman's breasts should be used in order to facilitate the feeding of the child throughout the period of lactation. An essential part of equipment bras, particularly in the first period of confinement, are nursing pads [1, 2]. Their main task are:

– absorption of surplus milk between the sessions of breastfeed;

– keeping dry woman skin as well as her underwear;

– maintained of physiological and psychological comfort.

These pads are placed into a bra and changed during every breast feeding.

During lactation one of the most common diseases is a postpartum mastitis. It affects about 1.4 % to 8.9 % of breastfeeding women [3, 4]. The first, main symptom is the increase of skin temperature within the female breast. The temperature of the diseased breast often exceeds 38 °C, but can also be high as 40 °C. When the start of treatment is delayed, the risk of complications are accrued from 8 % to 66 % cases [5]. Depending on the time of diagnosis, disease may occur at mild or requiring surgical intervention [5, 6]. A key to avoiding such complications is early diagnosis and quick treatment. Therefore, the novel, smart and intelligent nursing pads were created. These pads will be in non-invasive and effective informed of the possibility of pathological changes in the woman's breast, thereby preventing, in the early stages, the above-mentioned diseases.

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2. MATERIALS AND METHODS OF INVESTIGATION

Experimental investigations were carried out with 7 kinds of commercial disposable non-woven nursing pads, which are available on Polish market. All tested disposable nursing pads are composed of two layers: the surface layer and inner layer. The surface layer is a flat thermoplastic nonwoven. flat nonwoven fabric. The inner layer is a layer of absorbent, which is a fibrous pulp. Their characteristics are presented in Table 1.

Table 1. Characteristics of the tested nursing pads

No	Raw materials	Diameter, mm	Area density, g/m^2	Thickness, mm	Mass density, g/cm^3
1	100 % cotton	103.0	349	4.64	0.075
2	surface layers: 100 % polyester layer of absorbent: 100 % cotton	104.0	294	6.72	0.044
3	100 % cotton	101.0	387	7.39	0.052
4	100 % polyester	100.5	354	7.26	0.049
5	surface layers: 100 % viscose layer of absorbent: 100 % cotton	102.0	293	5.99	0.049
6	100 % cotton	105.0	384	6.89	0.055
7	100% viscose	99.5	410	7.02	0.059

* Corresponding author. Tel.: +48-33-8279188; fax.: +48-33-8279100.
E-mail address: *mboguslawska@ath.bielsko.pl* (M. Boguslawska-Bączek)

The research program included two parts [7, 8]:

1. Assessment of the following properties of nursing pads:

– permeability of air – according to standard PN-EN ISO 9237:1998 [9];

– resistance of the leakage – according to standard PN-P-85071-192, point 5.3.7 [10].

2. Modification of nursing pad and investigation of changing properties.

The pads from Table 1, which characterized by the best physiological properties was chosen for modification. In this part of investigations 4 types of modifications nursing pads with the different density of modifier points were performed (Figure 1). The density of points modifier was appropriate:

a) for the Version A the number of points was $n_1 = 6$;

b) for the Version B the number of points was $n_2 = 9$;

c) for the Version C the number of points was $n_3 = 12$;

d) for the Version D the number of points was $n_4 = 15$;

The modifier point had circular shape with a diameter of $d = 10$ mm. The modifiers were applied by fusing at the surface of interior layer of pads to guarantee a close contact with breast skin. The modifier points were distributed on the pads on a regular way. Variants of points' modifier deployment at the surface of nursing pad were dictated by the anatomical construction of the breast and way to the location of hot spots occurring.

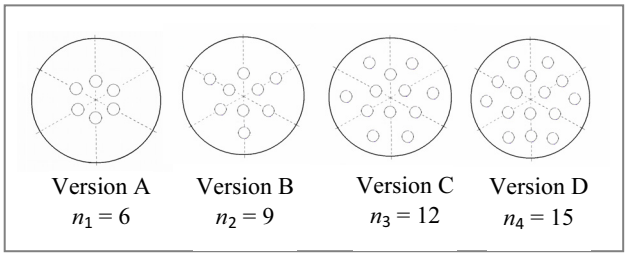

Fig. 1. Versions of points' modifier deployment at the surface of nursing pad

The thermoplastic elastomeric (TPE) with addition of termochromic pigment was used as modifier. The termochromic pigment changes colour during the temperature increase [11]. The chemical composition of modifier used in research was 99 % TPE and 1 % termochromic pigment. Selection of the modifier was dictated by the specific characteristics – visible change of colour under the influence of increasing temperature in the scope investigated and tested harmless for humans. Depending on temperature increase the used modifier changed colour from violet to pink.

3. RESULTS AND DISCUSSION

The first step of the investigations was to estimate on the selected hygienic properties of nursing pads. Air permeability and resistance of the leakage of nonwoven pads has been investigated according to standards [9, 10].

The measurement of air permeability was carried out on device TEXTEST FX 3300 in two directions: from the outside to the inside the pad (Oc) and from inside to outside the pad (Ic), using vacuum $P = 100$ Pa. The results are presented in the Figure 2 according to increasing mass density.

Based on the obtained results of measurement of air permeability it can be concluded that the tested inserts were characterized by very different values of this parameter. The highest air permeability was found for a pad no. 3, which was entirely made from 100 % cotton and was characterized by the lowest mass density. The smallest air permeability had the pad no. 1, which was also made of cotton, but was characterized by the highest mass density. Almost the same level of air permeability was demonstrated by pad no. 4 made of 100 % polyester and pad no. 5 made of polyester surface layer and cotton layer of absorbent. Both of them had the same value of mass density. Generally the difference in the obtained results between the pads no. 1,2 and 4 in comparison to the pads 3 and 6 were more than 95 %, so the first two were almost impermeable to air. The pads 5 and 7 demonstrated the middle permeability of air. These pads were made of viscose or viscose/cotton and had the middle mass density from the analysed nursing pads. Thus, based on the achieved results it can be concluded that the value of nursing pad air permeability is affected by the type of used fibres and the manner of their packing.

Additionally, it can be said that regardless of the type of pads, the air permeability varies depending on the direction of air flow – for the direction from the inside to outside (Ic) was higher than from outside to the inside (Oc). This is a good feature, which ensures adequate ventilation for the skin women's breasts, simultaneously providing the necessary insulation improving the user's physiological comfort nursing pads.

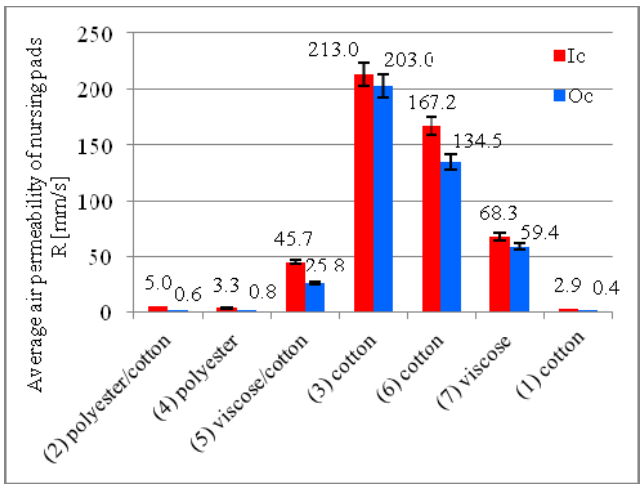

Fig. 2. The diagram of average values of air permeability of the tested nursing pads

Resistance of the leakage determines the amount of fluid absorbed by the material until the appearance of wet spots on its underside. The resistance of the leakage of tested nursing pads are presented in the Figure 3.

As with the assessment of air permeability, the best resistance of the leakage was obtained for pad no. 3, although the differences in the values were not so big. This value significantly affects the type of fibres used in the absorbent layer. The best results were obtained for the surface and absorbent layer made of cotton fibres. The

worst result was for pad entirely made of polyester. Resistance of leakage is a feature that makes a significant contribution to the hygiene of a bra, which, by securing an absorbent pad, could be used by longer period, ensuring nursing mother's well-being and psychological comfort in the period between successive seasons of feeding.

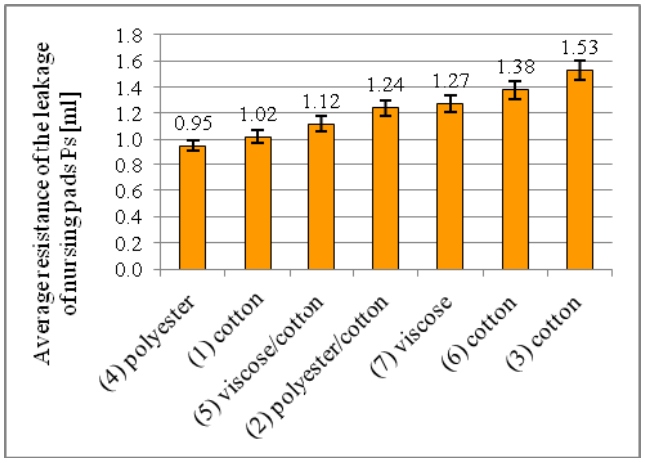

Fig. 3. The diagram of average values of resistance of leakage of the tested nursing pads

The next step of the research was the modification the best of the testing pads. To modify the selected pad no. 3, which was characterized by the best air permeability and the best resistance of the leakage. The investigation was careered focusing on two aspects of the modified nursing pads. The first aspect involved assessing the effectiveness of modification in the analyzed temperature changes. The second aspect was the impact of modifications on selected hygienic properties of pads.

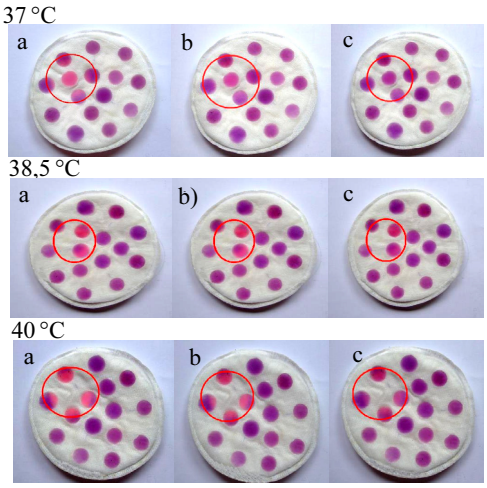

Fig. 4. The example of activity modification in the tested scope of temperature for the pad in version D ($n_4 = 15$): a – view discoloration at a given temperature; b – view discoloration after time 30 s; c – view discoloration after time 60 s

According to medical publications it can be concluded that the first noticeable symptom is an increase in breast skin temperature [3 – 5]. The temperature of infected woman's breast usually exceeds 38.5 °C but sometimes could reach even 40 °C. Therefore, the modified nursing pads were subjected to investigation, consisting of a gradual local heating by a spot electrical heater with thermostat. Then assessed whether a given temperature range is followed by visible changes in colour modifier, as well as what is the time to changes have become visible and when they disappear. The analyzed temperature ranged from 37 °C to 40 °C. Measuring and monitoring was conducted with a step 0.5 °C. The results are shown in Figures 4.

Analysing the obtained results it can be concluded that even at 37 °C were visible light, noticeable changes in colour modifier between the area of higher temperature and the rest of the pad providing a local increase in temperature around the mammary gland. At room temperature the colour differences were still noticeable after 30 seconds, and disappeared after 60 seconds. With the increase in temperature to 38.5 °C, the changes were more visible, although the area did not yet include all the points. The colour differences were visible even after 60 seconds of its staying at room temperature. As a result of temperatures of 40 °C colour changes were the most visible and involve not only the whole point of the modifier, but also the edge of neighbouring points.

After the modification, its influence on the selected hygienic properties of nursing pads was estimated and compared with the corresponding values of the same properties of without modification pads. The results of the changes of values of air permeability and resistance of the leakage are presented in the Figure 5 and Figure 6.

In case of measurement of air permeability of modifier pads was observed decreasing of the value with each successive modification versions (Figure 5). This dependency is dictated by the increase in the number of polymer elements and thus increasing the surface resistance to the flowing air stream. The maximum decrease in air permeability in relation to the pad without modification was $\Delta R_{Oc} \cong 21$ %. It was found for the version D (density of modifier points $n = 15$) in direction from the outside to the inside. For the same variant from the inside to outside, this difference was $\Delta R_{Ic} \cong 18$ %. According to the results, it can be observed that decrease of air permeability was not large, and still higher than other nursing pads, which were tested at the first part of these research (compare with the results in Figure 2).

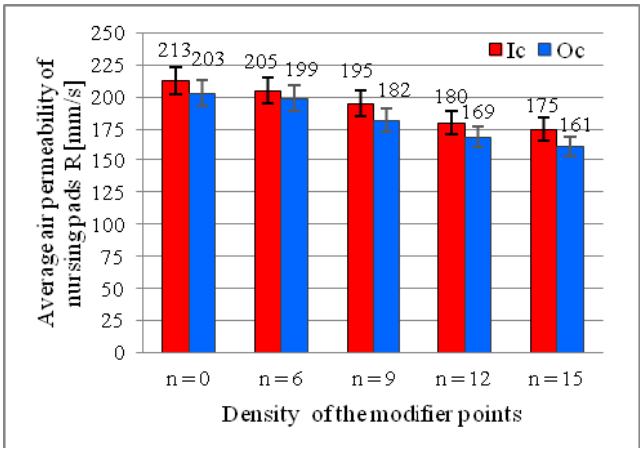

Fig. 5. The diagram of average values of air permeability of the modifier nursing pads

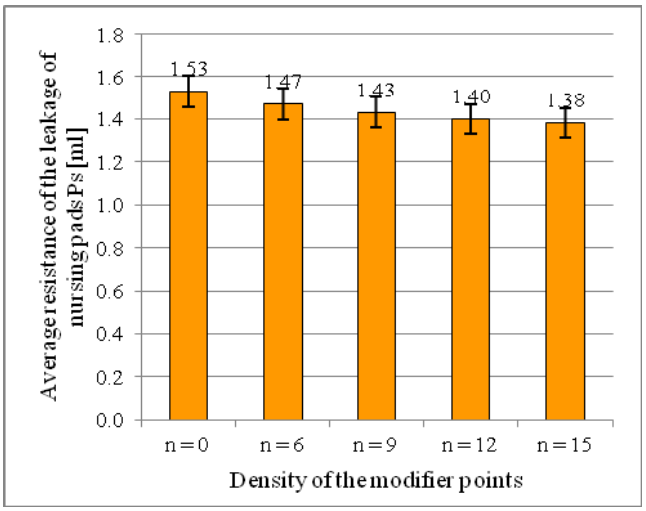

Fig. 6. The diagram of average values of resistance of leakage of the modifier nursing pads

Resistance of the leakage also decreases with increase in the number of modifier points (Figure 6). In the extreme case for version D (density of modifier points n = 15) decrease in resistance of the leakage in relation to the pad without modification was $\Delta Ps \cong 10$ %. In subsequent versions decreases of it were adequately: $\Delta Ps_{W/A} \cong 4.0$ %, $\Delta Ps_{A/B} \cong 3.0$ %, $\Delta Ps_{B/C} \cong 2.0$ %, $\Delta Ps_{C/D} \cong 1.5$ %. Thus, the greatest decrease of resistance of leakage was observed between the pad without modification and the modified pad of version A (density of modifier points $n = 6$). Generally, however, pads on the all versions were characterized by very good resistance of leakage and still higher than other tested pads (compare with the results in Figure 3).

4. CONCLUSIONS

Nursing pads used in bras for the duration of lactation fulfil a very important role in the hygienic, providing comfort physiological and psychological nursing mother, therefore they should be characterized by good air permeability and adequate resistance of the leakage. As demonstrated above presented research on the market there are nursing pads of varying quality. The best hygienic features are characterized by pads consisting entirely of cotton fibres with a relatively low packing density.

Since the lactating breast is exposed to various diseases – mostly postpartum mastitis, whose first symptom is an increase in skin temperature of diseased breast, this paper presents a new modified nursing pad. The modification of nursing pads provides the possibility of a non-invasive and very clear to inform women about the appearance of the local temperature rise and thus gives the possibility of early diagnosis of mastitis. The modification is based on the modifier, which changes colour with increasing temperature in the tested scope. The minimum recovery time for the discoloured area is sufficient to be able to see these changes and, consequently, to take appropriate preventive action. Additionally investigations have shown that the modification does not deteriorate hygienic properties to such an extent that impair the original function of tested pads.

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