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Design and Materials Selection: analysis of similar sanitary pads for daily use

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ABSTRACT
Hygiene practices have effects on vulvovaginal microbiota. Specific products for intimate female hygiene are available in the market, such as the sanitary pads. Since these pads were introduced in the market , they became the focus of research that seek to improve their shape, manufacturing processes and the properties of materials used in order to provide more benefits to users. Thus, the present study aimed to characterize the fabrics used in daily sanitary pads, focusing on the development of future products. The spectra generated by FTIR/ATR suggest that the samples were composed of polypropylene. The photomicrographs showed that the polymeric outer layer was made of nonwoven fabric manufactured by spunbond and point bonding processes.
Keywords: product design, material selection, analysis of similar sanitary pads.

I. INTRODUCTION

The vulva is a complex structure that provides the interface between external environment and the internal portion of the female genitals. Due to exposure, the vulva is susceptible to diseases that may even compromise the female reproductive development and functions. One of the defense mechanisms in the prevention of infections in this area is the composition of the vaginal microbiota. Several factors, including hygiene practices, may contribute to the increased instability of the vaginal ecosystem.

For women, these practices include bathing and drying of the whole body and hygiene of the genital area after urination/defection and during menstruation. In a study with American women, Czerwinski [1] pointed out that most of them make use of sanitary pads for daily genital hygiene.

Many doctors claim that the daily use of sanitary pads may prevent proper ventilation, increase the local temperature, and change vaginal pH, potentially leading to the development of vulvovaginal infections. However, new researches have indicated that a continuous daily use of sanitary pads does not increase recurrences of vulvovaginitis, bacterial vaginosis, vulvovaginal irritation or inflammation [2-5].

Research conducted on the textile sector may improve the properties of materials and processes used in sanitary pads for everyday use. In recent years, researchers have investigated the use of functional textiles in the areas of health, hygiene and beauty. Textile materials that have in their composition elements of body care, fitness and health are known as "cosmetic textiles". On contact with human body and skin, these textiles transfer an active substance for cosmetic purposes [6-13].

Therefore, the present study aimed to characterize the materials used in the top sheet of sanitary pads available in the market. The results obtained from the analysis can be used as a future reference for processing and for materials selection used in products with similar characteristics. Nevertheless, the knowledge of some physic-chemical and morphological properties of sanitary pads for daily use can be helpful in determining procedures for the improvement of these products design.

II. THE EVOLUTION OF SANITARY PADS

Sanitary pads have been used for thousands of years. These pads were made of soft material to absorb menstrual discharge. The ancient Greek physician Hippocrates mentioned in his manuscripts the use of tampons. For centuries, the methods of menstrual protection have not evolved: women often used strips of cloth or rags to provide menstrual protection which they would wash and reuse [14].

The first disposable sanitary pad was created (without success) by Johnson & Johnson in 1896. The Kimberly-Clark Company put Kotex on the market in 1921. Meanwhile, Johnson & Johnson introduced Modess®. These disposable absorbents were extended front and back so as to fit through loops in a special girdle or belt worn beneath undergarments. The first major improvement in disposable sanitary pads came around 50 years later when an adhesive was included underside the product to ensure it would remain in the same position [3, 14-22].

With the technological advances, the industry started to manufacture thinner pads made of cotton wool mixed with special polymer crystals (polyacrylamide and sodium polyacrylate) designed to absorb liquid. Once liquid enters the pads, the polymer crystals absorb it turning it into a gel-like substance and trapping it inside. The next step was the development of more comfortable and safer products. In the 1990s, the industry introduced innovations such as wings on maxi pads, with wraparound edges that fold under to fit multiple panty style [3, 21].

Recently, several studies have been carried out in order to improve the characteristics of sanitary pads. One of the main concerns is to lock away odor [23-31]. Improvements are also being made with regard to the absorption of fluid [32, 33].

III. MATERIALS AND METHODS

Fig. 1 shows the basic structure of sanitary pads. It consists of a top sheet layer that allows the passage of organic fluids, an absorbent layer and an underlying adhesive layer used as structural support.

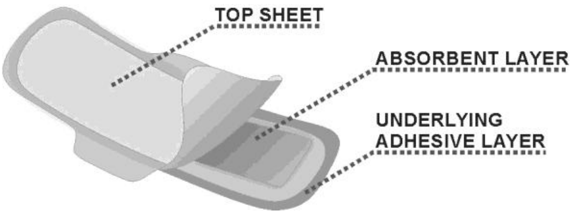

Fig. 1 Basic structure of sanitary pads.

The present study was carried out using six top sheet of sanitary pads available in the market. The materials characterization was performed by the analysis of the chemical composition, morphology and the rate of capillary absorption.

The chemical composition analysis was performed using the technique of Attenuated Total Reflection in conjunction with Fourier Transform Infrared Spectroscopy (ATR-FTIR). Sixteen cumulative readings were made from each sample, over the wavelength range of 4000-650 cm^{-1}, in transmission mode (Perkin-Elmer® Spectrum 100).

The top sheets morphological analysis was performed using a Hitachi® TM 3000 Scanning Electron Microscope (SEM). The magnified images (X50) allowed the analysis of the structure and manufacture aspects of the material under study.

The rate of capillary absorption of water is among the tests prepared by the Brazilian Standards NBR-13735:2006 [34] that proved to be adequate to evaluate this parameter in nonwoven. This material is often used in products that are directly in contact with the skin, therefore, it is of fundamental importance that the liquid moisture (mucous, urine, blood or sweat) flows quickly through the nonwoven, reducing the moisture built up in the microclimate. So the top sheet samples were partially immersed in distilled water at selected times (10, 30 and 60 seconds) to measure the height attained by the water.

IV. RESULTS AND DISCUSSION

For the trials, it was necessary to separate the top sheet layer from the other parts of the sanitary pads samples. Most of the six pads analyzed (samples 2, 3, 5 and 6) had only a few adherence points between the top sheet and the absorbent layer, which was thicker and slightly compressed. In contrast, samples 1 and 4 had a more compressed and homogeneous absorbent layers. It should be observed that the total thickness of the sanitary pads was determined mostly by the thickness of the absorbent layer. The process of separation was made difficult by these characteristics, and the top sheet samples were contaminated with the absorbent material (cellulose). Moreover, it was observed that, in the nonwoven, the web was stretched transversely in samples 1 and 2, and in the remaining ones, longitudinally.

After the samples of top sheet were separated from the sanitary pads, the analysis of the chemical composition was performed. The spectra generated by ATR-FTIR from the scan area (Fig. 2) showed that samples 1, 3, 4, 5 and 6 were composed of polypropylene $(C_3H_6)n$. Samples 2 and 6 showed the presence of cellulose $(C_6H_{10}O_5)n$. It was probably some residue from the absorbent layer.

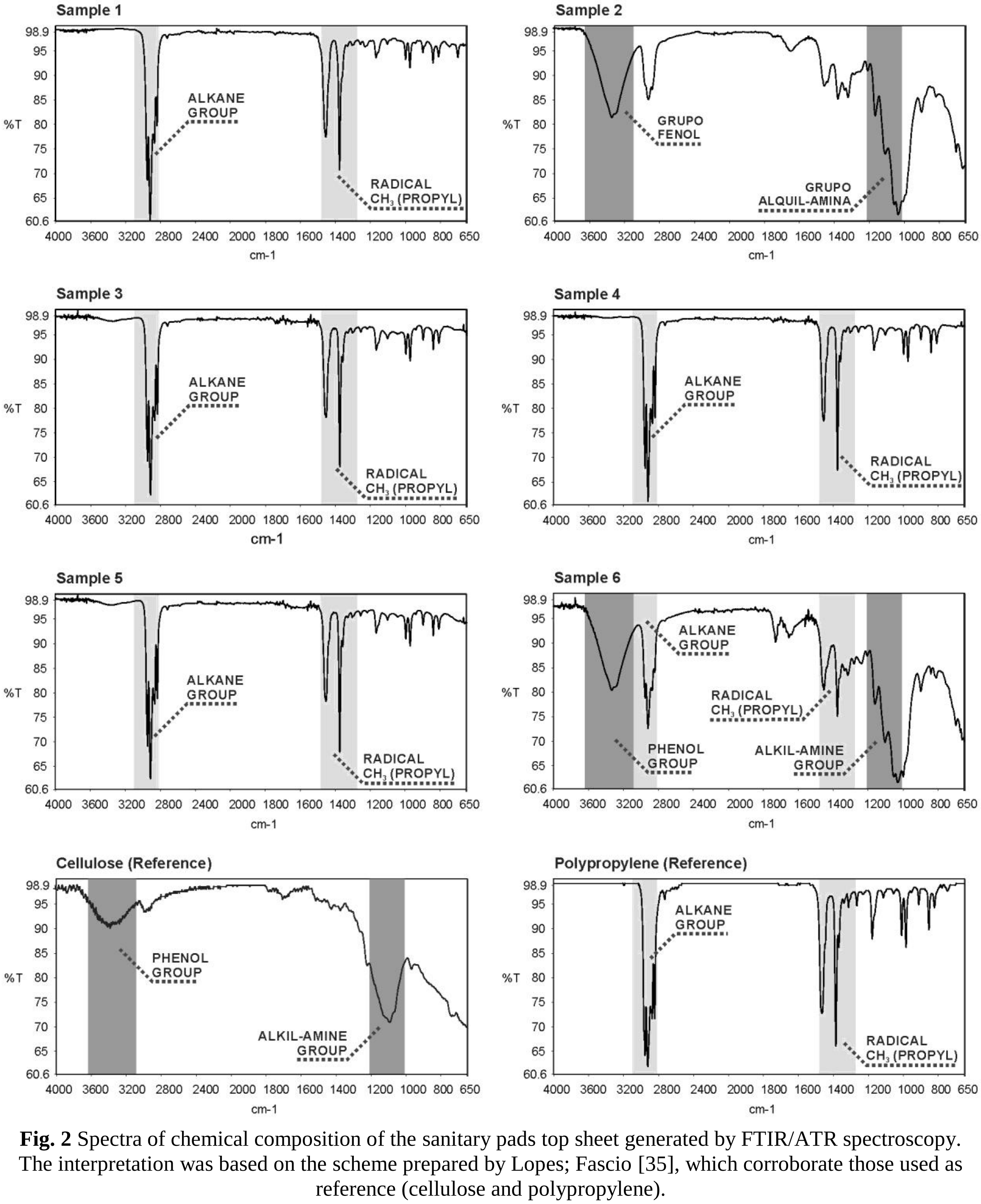

Fig. 2 Spectra of chemical composition of the sanitary pads top sheet generated by FTIR/ATR spectroscopy. The interpretation was based on the scheme prepared by Lopes; Fascio [35], which corroborate those used as reference (cellulose and polypropylene).

The SEM analyses made it possible to identify the morphological aspects and the manufacturing process of sanitary pads top sheet. The material photomicrographs (Fig. 3) magnified 50X revealed plates of aggregate material, apparently bonded. This is one of the morphological characteristics of materials known as nonwoven fabrics (NWF).

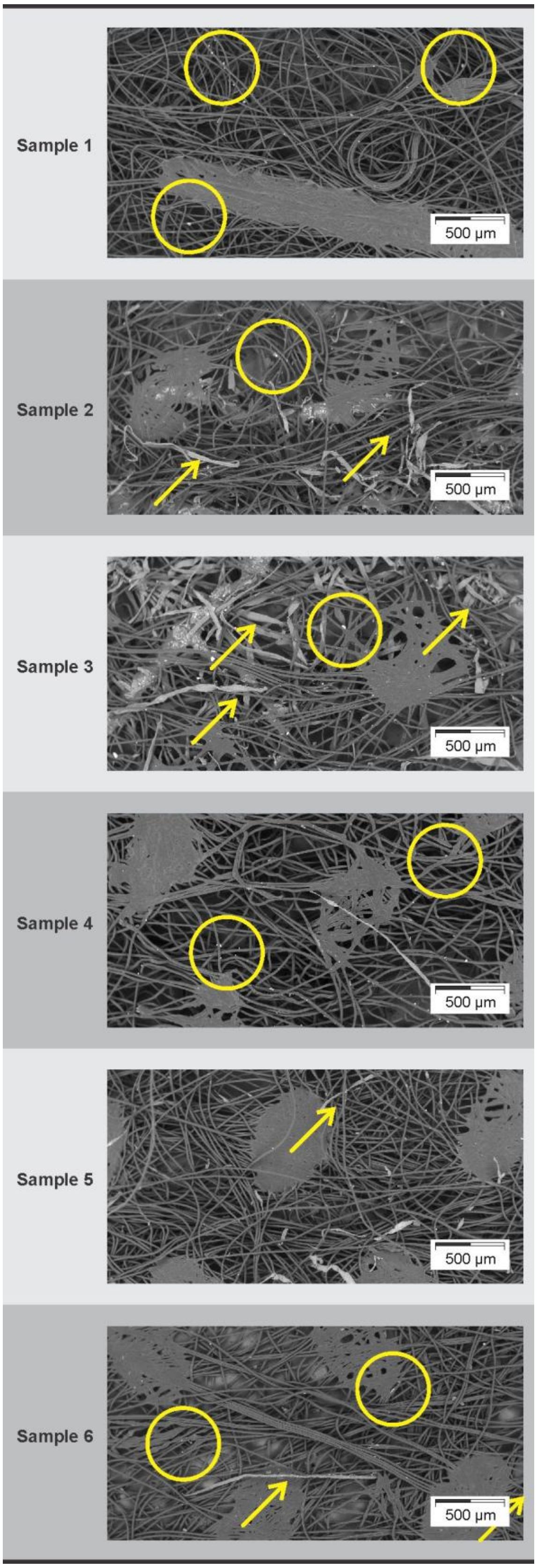

Fig. 3 Photomicrographs of sanitary pads top sheet. Arrows indicate cotton fibers intertwined to polypropylene; circles show contaminant particles.

The NWFs are widely applied in personal care and hygiene products due to their ability to absorb moisture. NWFs are disposable, comfortable and can be fabricated faster. Although the NWFs are made up of fibers and filaments, these materials differ from textile fabrics, because their fibers are not knitted, woven or plaited [36-39]. In accordance to Brazilian Standards [40], "the nonwoven is a flat, flexible and porous structure consisting of a mat or veil of fibers or filaments directionally or randomly oriented, consolidated by mechanical means (friction) and / or chemical (adhesion) and / or thermal (cohesion) and combinations thereof".

SEM photomicrographs of the analyzed material showed that it was manufactured by spunbond and point bonding processes, as described by Gupta; Smith [20]. It was also observed that the samples were contaminated by small particles. However, the analysis of the substrate morphology was not able to determine whether it was dust or cellulose from the absorbent outer layer. Additionally, with the exception of sample 1, the other samples had interwoven cotton fibers in their structure. The cotton fibers have a flat irregular shape and can be easily visualized in the midst of the regular polypropylene fibers.

According to Alcântara; Daltin [38], cotton consists of mainly cellulose, with a large number of hydroxyl groups, and is highly absorbable due to its hydrophilic nature. Therefore, it is believed that the incorporation of this material is intended to improve both the tactile and the absorption aspects.

To obtain the rate of capillary absorption, the NWF samples were partially immersed in distilled water at selected times (10, 30 and 60 seconds) to measure the height attained by the water. Three specimens were tested for each sample. Fig. 4 shows the mean values obtained.

In general, samples 1 and 2 presented higher capillary rates, absorbing up to 1.66 mm in 60s.The maximum height of capillary rise in the other samples was 0.66 mm. It is believed that this result is due to the fact that sample 2 had ingredients that could interfere with water absorption. However, no relationship was found between the composition of sample 1 and the amount of water absorbed. Moreover, it was observed that there was not a pattern of water absorption by capillarity of the evaluated materials.

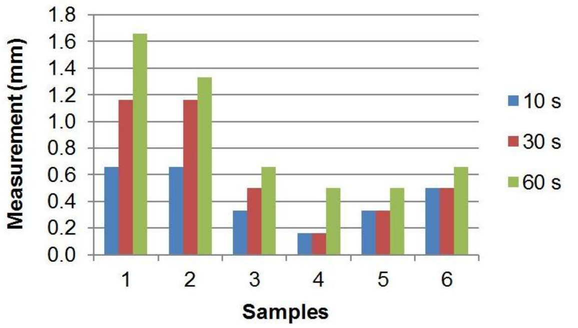

Fig. 4 Capillary rate measurement (mm) of sanitary pads top sheets. It was taken at 10, 30 and 60 seconds. Each bar corresponds to the mean of three samples.

V. CONCLUSIONS

The spectra generated by ATR-FTIR showed that samples 1, 3, 4, 5 and 6 were composed of polypropylene. Samples 2 and 6 showed the presence of cellulose $(C_6H_{10}O_5)n$, which was probably some residue from the inner lining. The SEM photomicrographs of the analyzed material showed that the top sheets were composed by nonwoven fabric and they were manufactured by spunbond (a direct conversion of a polymer into continuous filaments) and point bonding (a process of binding thermoplastic fibers into a nonwoven fabric by applying heat and pressure). Contaminants and particles of cotton fibers were found in most samples. There was not a pattern of water absorption by capillarity of evaluated materials.

The present study described some of the physicochemical and morphological characteristics of the materials used in sanitary pads top sheet for daily use. The data obtained from the analyses can assist in the design, manufacturing processes and material selection of future projects for intimate hygiene products.

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