

# Functional Design of Medical Undershirt with Microbial Barrier

**Beti ROGINA-CAR\*, Slavica BOGOVIĆ**

University of Zagreb Faculty of Textile Technology, Department of Clothing Technology, Prilaz baruna Filipovica 28a, 10000, Zagreb, Croatia

\*beti.rogina-car@ttf.hr

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## **ABSTRACT**

*Underwear is a very important segment for people with sensitive skin and patients with dermatological diseases. Since it is in direct contact with skin, it has an important role in the postoperative period, in which it is used as a function of protection and support of the operative part of the body. The main task of the underwear for this purpose is to protect the skin from harmful effects such as microorganisms and to keep the skin's condition in remission if no improvement can be achieved. In accordance with the specific requirements, a functional design of a medical undershirt with microbial barrier was proposed. Functional design was carried out based on previously published research. Digitization of the human body was carried out by 3D scanning and based on the cloud of points measures have been taken as well as defined forms of body parts for whom the cutting pattern is being developed. The model is divided into several zones where it is possible for each area to determine the required compression for the support.*

## **KEYWORDS**

*Functional design, computer clothing construction, 3D body scanning, microbial barrier, medical undershirt*

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## **INTRODUCTION**

Underwear is a garment that is worn in direct contact with skin. It is exposed to the influence of microorganisms from the environment and from the carrier itself. Therefore, it is necessary to select a suitable material with the appropriate microbial barrier. Underwear is mostly made by knitting. The knitwear is very adaptive to the shape and size of the body, due to its structure. Underwear that covers the body after injury, surgery or a chronic dermatological picture has a specific function. The laundry needs to provide adequate protection from infections and irritation that can worsen the dermatological image or to a great extent slow down the recovery of the patient. The functional design is obtained by necessary acceptance or underwear that follows the shape of the body and provides the necessary support. The properties of the selected material and the shape of the laundry must minimize negative impacts on the recovery of the patient.

The use of wood based cellulosic fibers enables the creation of products that are able to achieve a balance between sustainability and performance. Biodegradability Lyocell fiber is an important criterion for use in segments such as cosmetics and hygiene. They are therefore an ideal alternative to conventional materials. Such high quality textiles are used for medical and sports wear, covers, sheets and pillows [1].

Tencel® is an excellent alternative to cotton and has an important position on the textile market: in manufacturing of clothes, clothes, bed linen, towels etc. Also to be used in technical textiles: nonwoven fabrics and foil [2-4]. Tencel® is also Lenzing's flagship brand for textiles. It is used for a variety of highly specialized applications due to its specific properties: it gives a soft skin feeling, its smooth upon touch, it has an extraordinary capacity for heat regulation and moisture absorption. Cotton absorbs much less water than Tencel®. Tencel® consists of countless, highly hydrophilic, crystalline nano fibrils, which have a fixed arrangement. Fibers do not absorb water but absorption occurs only in capillaries between fibrils. The water distribution at Tencel® is very unique: it absorbs water over the entire cross-section of the fiber. The reason for such behavior Tencel® are pores that are uniform in the nanometer range. Such properties provide a natural mechanism for thermal regulation of the body. The skin's feel is warm and dry. Compared with polyester and synthetics, a small amount of moisture remains on the surface of the fiber. It provides a less favorable environment for bacterial growth and offers better hygiene properties of textiles [1, 3, 5-9]. Such properties make it an ideal choice to use in medicine.

In the work of author Diepgen and Schuster 30 patients with atopic dermatitis and 30 psoriasis patients were wearing Tencel® textile for a week. All textile products were commercially available without special refinement. The results showed that during the study period there was a significant improvement in dermatological skin images affected by atopic dermatitis and psoriasis. More than 90% of patients rated Tencel® much better and more compatible with their skin than their own clothes and linens. Improvement associated with itching, skin sensitivity, thermoregulatory properties, due to cold, smooth and dry skin sensation has been achieved. The conclusion is that it can be recommended not only for people with sensitive skin but also for patients with skin diseases, especially atopic dermatitis or psoriasis [10].

The aim of the research was to propose a functional design of Medical Undershirts with Microbial Barriers with respect to the previously explored properties of textile materials. Construction and modeling were carried out on the basis of the obtained results of the permeability of the microbial barrier. With the combination of textile materials, the required functionality is achieved. The woven fabric is used for those parts of the laundry that must have a support function, for example, an operative part of the body. Using the knitted fabric requires the necessary acceptance. Comfort is achieved by choosing a textile material made of 100% Tencel®. A proposal for new models of disposable Medical Undershirt with Propolis was given. Tencel® nonwoven with Propolis has antimicrobial activity. Additionally, Propolis is a natural antibiotic that provides a faster recovery for skin with dermatological problems. It is also recommended for use after operative procedures.

## **EXPERIMENTAL**

### **Materials and Methods**

In the research 100 % Tencel® made by Lenzing: woven fabric, Tencel® knitted fabric with Chitosan, Tencel® nonwoven fabric with Propolis and without it was used. The Sample II was post treated with a Chitosan solution (0.8%), Lenzing, Austria. Tencel® nonwoven fabric with Propolis have been developed for use in medicine and are described in detail in the literature [11]. In this paper, it is applied for the functional design of disposable underwear with microbial barrier and antimicrobial effect. The properties of the textiles used are shown in Table 1 [11-14].

Table 1. Properties of the textiles used

Samples			Surface mass, g/m <sup>2</sup>	Thickness, mm
Sample I	100 % TENCEL®	woven fabric, twill 2/1	193.7	0.34
Sample II	100 % TENCEL® with Chitosan	single jersey knitted fabric	280.0	0.43
Simple III	100 % TENCEL® with Propolis	nonwoven fabric	55.7	0.28
Simple IV	100 % TENCEL®	nonwoven fabric	55.3	0.23

*Permeability of microorganisms in dry conditions of extreme contamination*

Testing the permeability of the microbial barrier of dry textile material was conducted according to the newly developed method [11]. The samples are fixed into a ring device which is packed in a transparent sterilization package. After that, the samples are sterilized at 134°C for 5 minutes. The spores are rubbed down onto sterilized samples in aseptic conditions. Incubation follows for 24 hours, after that prints are taken with CT3P agar plates, first from the back side and then from the front side. The agar plates are incubated for 72 hours at 35°C, after follows the counting of bacterial colonies (CFU) [11].

*Defining body shapes and taking body measurements*

For the purpose of adequate design, 3D scanning of the human body was carried out using a 3D body scanner, whereby the male body was digitized and the geometric features and numerical data used in defining the shape and construction of the compression or support underwear were determined. For this purpose, the 3D body scanner VITUS smart was used, which was installed at the University of Zagreb, at the Faculty of Textile Technology, at the Department of Clothing Technology. The ScanWorx software package was used for this interactive computer-based work when taking measurements and points cloud cross sections to accurately define body shape.

**RESULTS AND DISCUSSION**

Figure 1. shows the results obtained by 3D scanning of male bodies, with visible variations in shapes and sizes. Cross-section measurements have been taken every 5 cm. In this way, we can get the necessary approval of medical clothing.

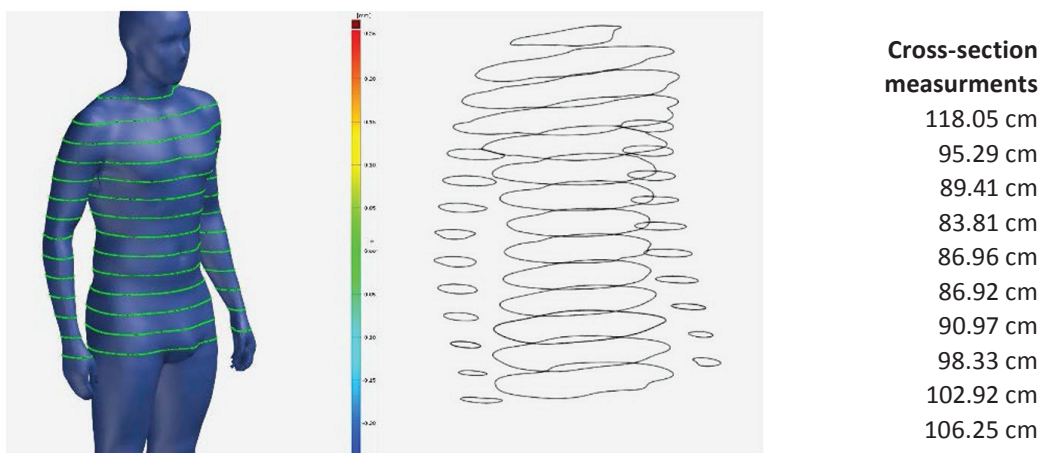


Figure 1. Shapes obtained by 3D scanning

The testing results of medical textiles to the permeability of microorganisms after extreme conditions of contamination with bacterial spores and thickness fabrics are shown in Figure 2., [11-14].

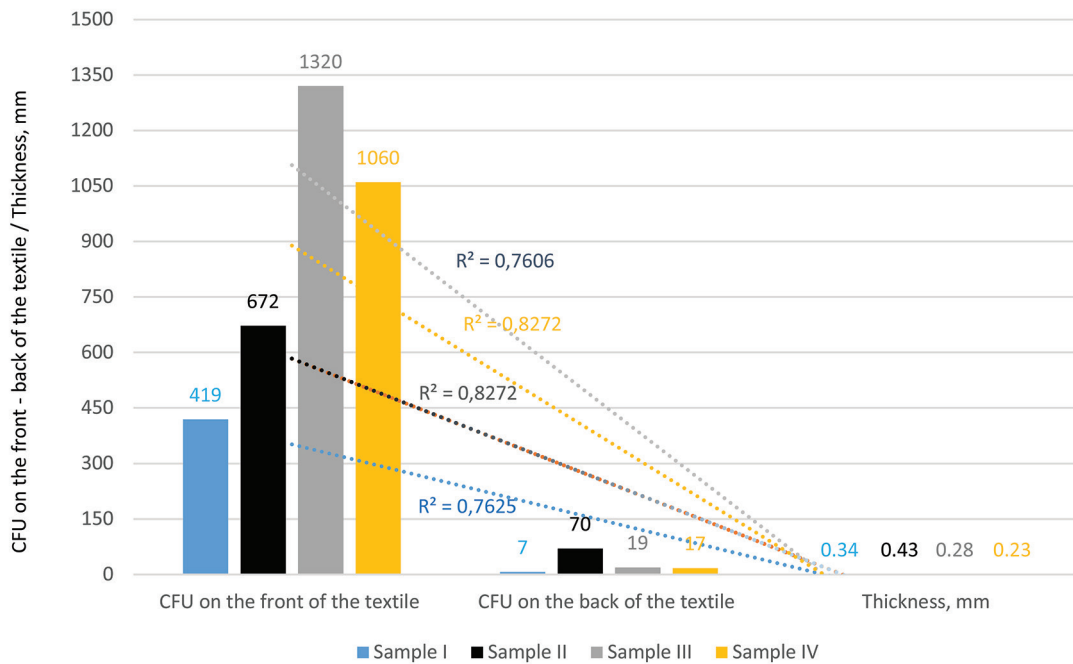


Figure 2. Results of medical textiles to the permeability of microorganisms and thickness fabrics

The properties of the microbial barrier are affected by the structure of the samples: woven fabric, knitted fabric, nonwoven fabrics. From microorganism permeability results, it can be concluded that the nonwoven structure has the smallest bandwidth. The reason is layered and densely arranged lyocell fibers that block the passage of microorganisms. The results show that knitted fabric has the highest permeability of microorganisms due to its specific cavity structure. The knitwear gives the required fit of underwear. The model of medical undershirts 1 and 2 has the required microbial barrier achieved using woven fabric, Figure 3. The microbial barrier woven fabric (Sample I) is in the ratio of 60:1 (Front - Back Ration CFU). While the ratio of bandwidths is 10:1. Given their mechanical properties that differ for models 1 and 2 that are designed to provide a good microbial barrier and the appropriate support, a woven fabric is used. Foreclosure is projected from the front with the help of a broad band strap that allows regulation of the support. The knitted fabric (Sample II), due to its elasticity, is intended for the construction of that part of the garment that has to follow the shape of the body and therefore gives greater comfort, especially in the change of body positions, Figure 3.

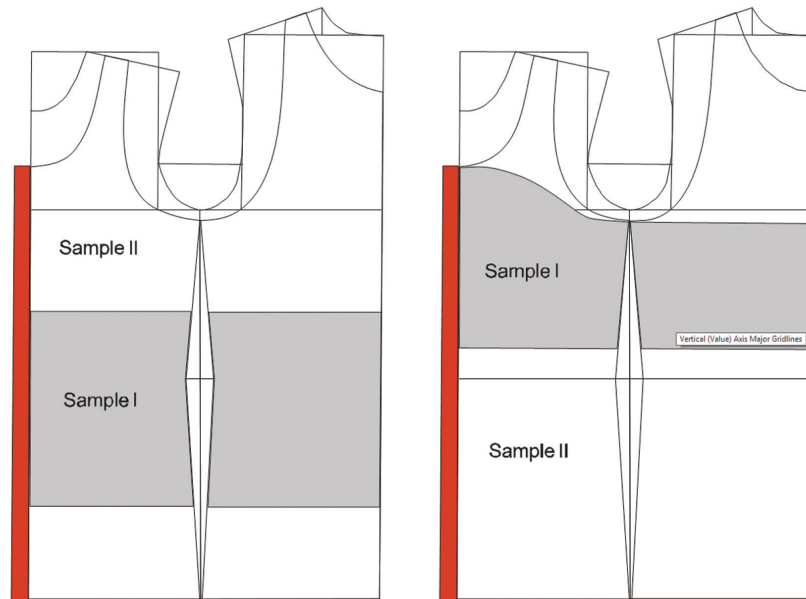


Figure 3. Construction and modeling of Medical Undershirt with Microbial Barrier: Model 1 i 2

Comparison of the results shows that the best results with respect to the microbial barrier and the time of absorption have Tencel® nonwoven fabric with Propolis and without it, (Sample III and IV) Figure 4.

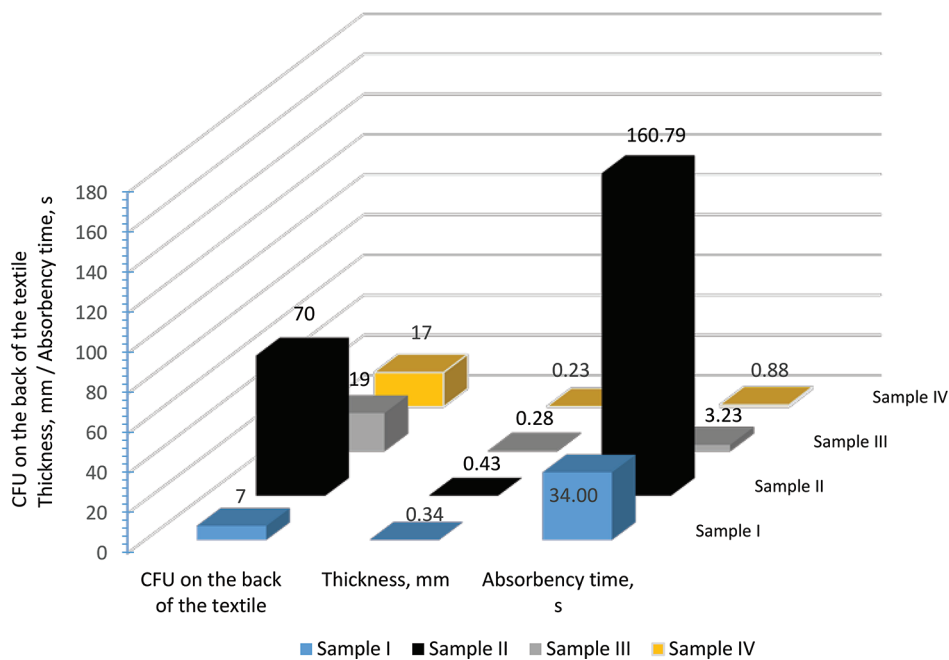


Figure 4. Comparison of results: number of microorganisms on the back of the textile, sample thickness and absorbency time

Their combination yielded three models of the disposable Medical Undershirt Figure 5-7. Tencel® nonwoven fabric with Propolis is intended for the affected or sensitive skin. Since Tencel® and Propolis are biodegradable, they are completely ecologically acceptable.

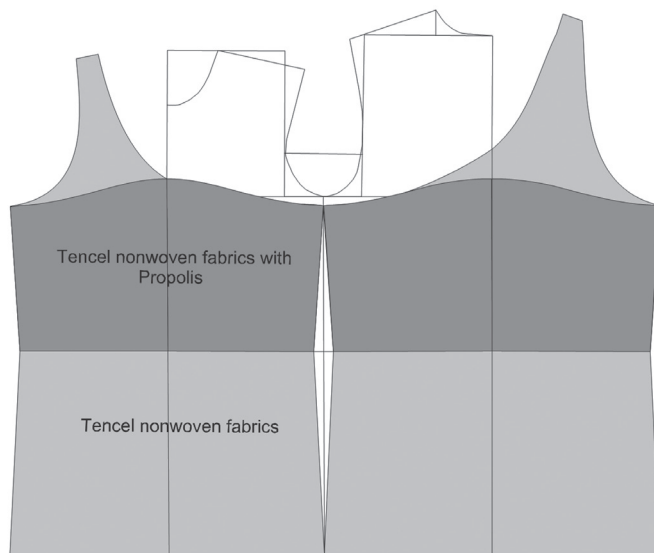


Figure 5. Construction and modeling of disposable Medical Undershirt with Propolis – Model

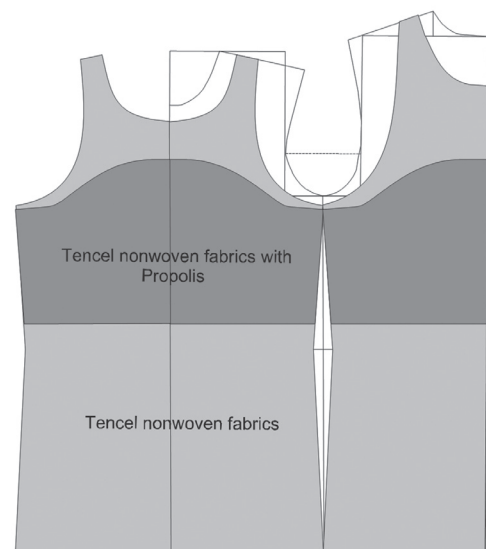


Figure 6. Construction and modeling of disposable Medical Undershirt with Propolis – Model 4

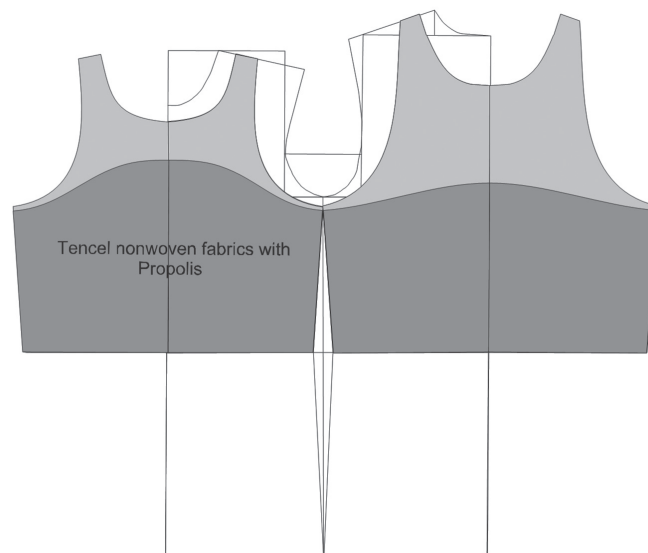


Figure 7. Construction and modeling of disposable Medical Undershirt with Propolis – Model 5

## CONCLUSION

Based on the results obtained through functional design and construction methods, and the combination of Tencel® woven fabric and knitted fabrics, a Medical Undershirt is provided that provides the necessary support, comfort and microbial barrier for the affected or operative body parts. The regulation of support is provided with a wide band strap. For the functional design of a disposable Medical Undershirt, a combination of Tencel® nonwoven fabric and a newly developed Tencel® nonwoven fabric with Propolis were used. Propolis is a natural antibiotic that provides antibacterial properties. Also the time of absorption is the smallest in this combination of materials, giving you additional comfort and a pleasant feeling on the skin. Also, time of absorption is very important for sweating and excretion caused by skin diseases. Since it is a disposable Medical Undershirt, the design proposal for using Tencel® is environmentally friendly. The

obtained models have the functionality and the required microbial barrier and can be proposed for use in medicine, but also for people with sensitive skin.

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