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# Antimicrobial and Blood-Repellent Finishes of Surgical Gowns

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**Abstract**

HEALTHCARE textiles are a major segment of medical textiles because they are one of the markets for technical textiles that are growing the fastest. To provide textiles an antibacterial, blood- and water-repellent finish, numerous classes of compounds have been created.. Our aim here is to treat pure cotton and polyester/cotton blended fabrics with perfluoro-heptyl-methacrylate (PFHMA) as well as magnesium oxide nanoparticles (MgONPs) to impart multifunctional properties to the fabrics. The treated substrates are tested by measuring the contact angle, microbial activity, and scanning electron microscopy to analyze the results obtained.

**Keywords** Medical Textiles, Healthcare Textiles, Blood Repellent Finish, Water Repellent Finishes, Antimicrobial Finishes

## Introduction

Today's viruses and bacteria are undergoing more varied and complex alterations, making it crucial to continue researching and developing medical protective apparel.[1-8] One of the fundamental requirements in the medical protection system is outstanding antibacterial and water-repellent performance.. [6, 9-11] This study analyses the current use of antibacterial and water-repellent protective clothing in terms of protective materials, processing technology, and technological intelligence by classifying the development history of medical protective clothing.

Materials that save energy and the environment, like MgO nanoparticles.[12, 13] Since they are non-toxic, made from easily accessible ingredients, and show tremendous promise as a new solid bactericidal material under straightforward circumstances, they are frequently employed in antimicrobial applications. Significant advancements and discoveries in this area of textile technology have been sparked by the development of nanotechnology. Through the use of nanotechnology, fabric finishing has taken on new directions and shown a huge potential for considerable advances. [14] Among the various functional finishes imparted by the nanoparticles, antimicrobial finishes in textiles prove to be beneficial in the health and hygiene sector as the inherent properties of the textile fibers provide a platform for the growth of microorganisms. [15, 16]

In this study, two types of fabrics, mainly pure cotton and 50:50 polyester/cotton (P/C) blended fabrics are used. Cotton fabric was treated with magnesium oxide nanoparticles (MgONPs) [9] to obtain antimicrobial finishing while cotton/polyester blended fabric was treated with a mixture of finishing agents to impart blood repellent. [17] finishing the

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fabric. All the required measurements are included and discussed in detail. [12]

**Material, Methods, and measurements**

***Materials***

100% cotton, as well as 50/50 cotton/PET blended fabrics, are kindly supplied by El-Mahalla Company for Spinning and Weaving, El-Mahala, Egypt.

Magnesium oxide (nanopowder, ≤ 50 nm particle size) was purchased from Sigma-Aldrich, Egypt.

Perfluoro-heptyl-methacrylate (PFHMA), dimethylol dihydroxy ethyl urea (DMDHEU), $NH_4Cl$, $CaCl_2$, and sodium alginate, all of the labarotry grade and are all purchased from El-Gomhouria Pharmaceutical Company, Egypt.

***Methods***

*Anti-Microbial Treatment*

Three concentrations of MgONPs are used (0.25, 0.5, and 0.75 g/L)
Calcium chloride:10 gm
Sodium alginate: 10 gm
Water 100 ml

The pad-dry technique is used to apply MgONPs to the fabric made entirely of cotton. The cloth was dried at 60°C for 5 minutes after being padded with foam to get a wet pick-up of 70%.

*Water/Blood Repellent Treatment*

Three concentrations of PFHMA are used (4, 5.5, and 7.5 g/L)
DMDHEU: 1.5 g/L
$NH_4Cl$: 15 g/L
Water 30 ml

A mixture of **(**PFHMA-DMDHEU-$NH_4Cl$) is applied to 50:50 polyester-cotton (P/C) blended fabrics by the pad-dry-cure method. The fabric was padded with the takeout to attain a wet pick-up of 70%, dried at 70°C for 5 min, and then cured at 150°C for 5 min.

***Measurements***

*Scanning Electron Microscope (SEM)*

Morphological properties SEM Quanta FEG-250 (Czech Republic). Using Quanta FEG250, field-emission scanning electron microscopy (FE-SEM) was used to examine the morphological characteristics of the pre- and post-treated textiles (Thermo Fisher Scientific, Brno, Czech Republic). By using a work distance of 21 mm and an acceleration voltage of 20 kV, this was fitted with energy-dispersive X-ray spectroscopy (TEAM-EDX Model) to examine the chemical makeup of the pre- and post-treated textiles.

*Contact Angle (Hydrophobicity Screening)*

On OCA 15 EC, the contact angle was reported (Dataphysics, Stuttgart, Germany). Using Quanta FEG250, field-emission scanning electron microscopy (FE-SEM) was used to examine the morphological characteristics of the pre- and post-treated textiles (Thermo Fisher Scientific, Brno, Czech Republic). By using various work distances and an acceleration voltage of 20 kV, this was outfitted with energy-dispersive X-ray spectroscopy (TEAM-EDX Model) to investigate the chemical composition of the pre- and post-treated textiles.

*Anti-Microbial Test*

The disc agar diffusion technique was used to investigate the antibacterial properties of cotton fabric. Staphylococcus aureus ATCC 6538-P (G+ve), Escherichia coli ATCC 25933 (G-ve), Candida albicans ATCC 10231 (yeast), and Aspergillus niger NRRL-A326 were the four typical test organisms employed (fungus). In the case of bacteria and yeast, nutrient agar plates were severely injected on a regular basis with 0.1 ml of 105-106 cells/ml. The antifungal properties were tested using potato dextrose agar plates inoculated with 0.1ml (106 cells/ml) of the fungal inoculum. The inoculation plates were covered with 15 mm diameter textile-treated discs. To allow for maximal diffusion, plates were then maintained at a low temperature (4°C) for 2-4 hours. The plates were then incubated for bacteria at 37°C for 24 hours and for organisms to develop as much as possible, at 30°C for 48 hours in an upright posture. The diameter of the millimeter-sized zone of inhibition was used to measure the test agent's antibacterial activity (mm). The experiment was run many times, and the mean value was noted.

**Results and Discussion**

All the measurements are applied using 0.5 g/l while, we used three concentrations of MgONPs (0.25, 0.5, and 0.75 g/l).

All the measurements are applied using 5.5 g/l while, we used three concentrations of PFHMA (4, 5.5, and 7.5 g/l)

***Morphology and Composition***

The morphological properties were studied by scanning electron microscope (SEM), using a concentration of 0.5 of MgONPs for treating cotton

fabrics, and the obtained results are demonstrated in figure 1. Notice in SEM images that happened roughness as a result of treatment by using (MgONPs).

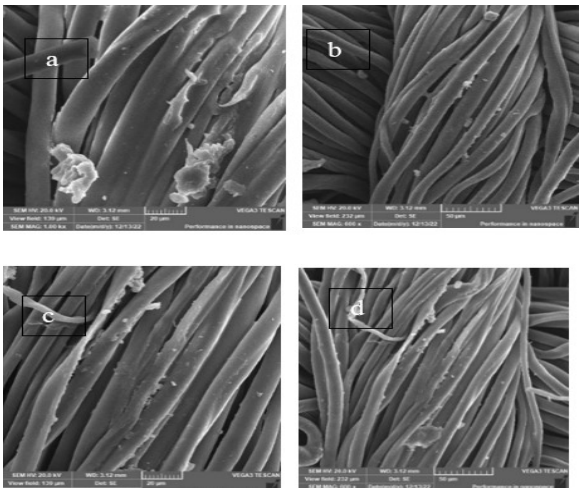



**Figure** 1**.** SEM images of treated pure cotton fabrics.

***Water and Oil Repellency***

The findings of the static contact angle measurements provided additional confirmation of the hydrophobicity and oleophobicity of the PFHMA-coated samples. Treatment of cotton/PET blended fabric was carried out using PFHMA at a concentration of 5.5 g/l. Water and diiodomethane left the samples mostly unwetted, resulting in a contact angle of 121.9. Since the high contact angles of n-alkanes were required to demonstrate surface oleophobicity, the contact angle of n-hexadecane was also tested and found to be 121.9.

***Anti-Microbial Activity***

The resulting antimicrobial activity testing is applied on cotton fabrics and demonstrated in table 1. The antibacterial activity against several test microorganisms including yeast (C. albicans), G+ve bacteria (S. aureus), G-ve bacteria (E. coli), and fungus (A. niger)

It can be concluded from the previous table that, a very high antimicrobial activity of metal oxide–coated substrate material against both types of bacteria (staphylococcus aureus, escherichia coli, candida Albicans, and aspergillus niger), according to the disc agar diffusion method.

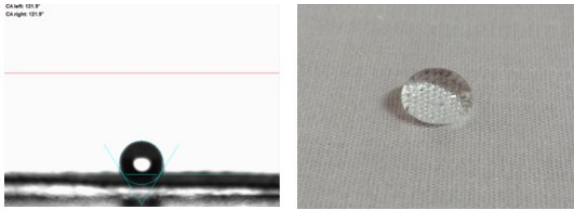


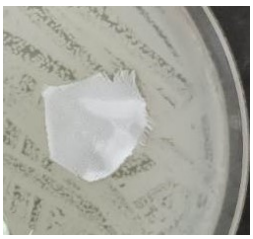
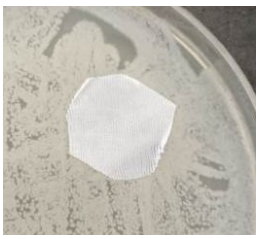
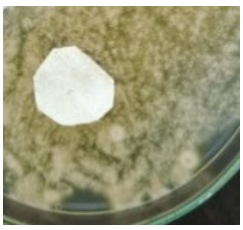
**Figure 2.** Cotton/polyester blended fabrics treated by PFHMA.

**Conclusions**

Smart coatings were deposited on cotton by using (MgONPs) as well as cotton/PET blended fabric by using (a PFHMA mixture), to impart antimicrobial and water-repellent finishings to the fabrics, respectively. To improve its ability to repel water and blood, cotton fabric was treated using the pad-dry-cure technique, while blended fabric also received this treatment.. Water repellent property was found to be greatly influenced by the PFHMA concentration of the treatment.

Studying contact angle hydrophobicity screening and scanning with an electron microscope were used to demonstrate the findings (SEM). The outcomes showed that the treated cotton/PET textiles have long-lasting water-repellent properties, opening the door to mass manufacture of water-repellent textile materials for a range of industrial uses.

Table 1: Antimicrobial activity testing

| Clear zone (ϕmm) | | | |
|---|---|---|---|
| *Staphylococcus aureus* | *Escheichia coli* | *Candida albicans* | *Aspergillus niger* |
| **16** | **0** | **25** | **0** |
|  |  |  |  |

**Conflict of Interest**

There is no conflict of interest in the publication of this article.

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# التجهيزات المقاومه للميكروبات والطاردة للدم للملابس الجراحية

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**المستخلص**: تعتبر منسوجات الرعاية الصحية من القطاعات الرئيسية للمنسوجات الطبية ، حيث إنها واحدة من أسرع القطاعات توسعًا في سوق المنسوجات التقنية. لذلك ، تم إدخال فئات مختلفة من المواد الكيميائية لإضفاء اللمسات النهائية المضادة للميكروبات والدم والماء على الأقمشة. هدفنا هنا هو معالجة الأقمشة المخلوطة من القطن الخالص والبوليستر / القطن باستخدام بيرفلورو هيبتيل ميثاكريلات (PFHMA) وكذلك جزيئات نانو أكسيد المغنيسيوم (MgONPs) لإضفاء خصائص متعددة الوظائف على الأقمشة. يتم اختبار الركائز المعالجة عن طريق قياس زاوية التلامس والنشاط الجرثومي والمسح المجهري الإلكتروني لتحليل النتائج التي تم الحصول عليها

**الكلمات المفتاحية:** منسوجات طبية، منسوجات الرعاية الصحية، التجهيزات الطارده للدم والمياه و المضادة للميكروبات