Gamma-rays shielding and antibacterial properties of coated fabrics

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ABSTRACT – REZUMAT

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Today, with the development of technology, radiation exposure is more common. Therefore, alternative methods have been developed because shielding, which is used as the most effective method for radiation protection, has risks in terms of health. With the awareness of consumers, the use of antibacterial textile products has increased in terms of hygiene and comfort. In this study, for this purpose nano-silver which has antibacterial properties was applied to woven fabrics with the impregnation method and the fabrics were coated with tungsten and barium sulfate, which have radiation shielding properties. The radiation shielding properties of fabrics against ^{137}Cs source emitting γ radiation were investigated. In this study, woven fabrics with radiation protection and antibacterial properties, which are very important for the health sector, were obtained and compared with each other.

Keywords: *radiation shielding, antibacterial property, woven fabric*

Proprietățile de ecranarea împotriva radiațiilor gamma și cele antibacteriene ale țesăturilor peliculizate

În prezent, odată cu dezvoltarea tehnologiei, expunerea la radiații este mai frecventă. Prin urmare, s-au dezvoltat metode alternative de ecranare, care sunt folosite ca cele mai eficiente metode pentru protecția împotriva radiațiilor, ce prezintă riscuri în ceea ce privește sănătatea. Odată cu conștientizarea consumatorilor, utilizarea produselor textile antibacteriene a crescut în ceea ce privește igiena și confortul. În acest studiu, în acest scop a fost aplicat nano-argint care are proprietăți antibacteriene pe țesături prin metoda de impregnare, iar țesăturile au fost peliculizate cu tungsten și sulfat de bariu, care au proprietăți de protecție împotriva radiațiilor. Au fost investigate proprietățile de protecție împotriva radiațiilor ale țesăturilor împotriva sursei de ^{137}Cs care emite radiații γ. În acest studiu, au fost obținute și comparate țesături cu proprietăți antibacteriene și de protecție împotriva radiațiilor, care sunt foarte importante pentru sectorul sănătății.

Cuvinte-cheie: *ecranare împotriva radiațiilor, proprietăți antibacteriene, țesătură*

INTRODUCTION

The energy emitted or transmitted in wave or particle form, in matter or space is called radiation [1]. There are natural and artificial radiation sources such as cosmic rays, radioactive elements in the human body, radon gas, gamma rays, radioactive materials taken from food, medical applications, nuclear power plants, and consumer products [2, 3]. Base stations, mobile phones, and Internet networks can affect the quality of life of all living things [4]. Radiation has serious biological effects such as radiation burns and diseases, hereditary disorders, shortening of human life, cancer and sudden death [5]. Radiation is used in the diagnosis and treatment of diseases, energy production, industrial products, agriculture, nuclear weapons, consumer products and forensic medicine [6]. Radiation, which is used in many areas today, besides making human life easier, it is necessary to be protected from radiation due to the risks it poses in terms of health.

Humans are in contact with a wide variety of microorganisms in daily life, and these microorganisms can reproduce very quickly with the effect of appropriate humidity, temperature and food. With the effect of microorganisms on textile surfaces, conditions such as stains, bad odour and loss of strength can be encountered [7]. With antibacterial textile products, it is desired to reduce and eliminate the negative situations caused by microorganisms on the textile surface and the damage that they cause to the user. Antibacterial textile products are especially preferred in environments such as hospitals and nurseries where microorganisms multiply rapidly [8]. Apart from killing microorganisms, the antibacterial substances used should not harm the user, the environment and the textile product [9].

Antibacterial textile surfaces are obtained by adding antibacterial substances to the fibre polymer structure and finishing processes [8]. Alcohols, metals, ammonium compounds, phenol and its derivatives, halogens, zeolites, oxidizing agents, biquanidins, isothiazolones, chitin and chitosan are the most important antibacterial agents [9]. Extraction, impregnation, spraying, foam application, vacuum application, maximum liquor application, transfer and coating methods are used in antibacterial finishing processes [10]. With antibacterial finishing processes, it is desired to prevent negative changes in fabric performance, limit bacterial re-growth, to prevent odour formation and the spread of pathogens [11].

In the field of radiation shielding, work is underway to develop materials that are lightweight, economical, non-toxic and have high shielding properties. Researchers have focused on many types of materials, from traditional materials to natural minerals, and composite materials to various building materials, such as the absorption of various types of radiation.

In some studies in the literature of Harish et al., different proportions of lead monoxide (PbO) and isophthalate-based unsaturated polyester resin composites were prepared and gamma ray absorption tests were performed from ^{137}Cs source. According to the test results, it was stated composites filled with PbO of more than 30% showed higher performance for gamma rays with an energy of 0.662 MeV than armour materials such as silver, copper and concrete [12]. In 2015, Badawy and Latif investigated the performance of composites containing polyvinyl alcohol (PVA) and magnetite (Fe_2O_3) nanoparticles in ^{60}Co, ^{137}Cs, and ^{22}Na gamma sources. As a result of the experiments, they stated that this composite film can be an alternative to lead due to its lightness and flexibility advantage [13]. Gülbicim examined the radiation permeability of samples created with vermiculite and different proportions of Borax mineral (25–50%) in his study. Using ^{60}Co (Cobalt), ^{152}Eu (Europium) and ^{226}Ra (Radium) radiation sources, it was noted that the boron-doped vermiculite sample at energy values in the range of 0.186–1.728 MeV showed higher performance than lead at energy values of 1–3 MeV [14]. As a filler Carbon Black (CB) and lead tungstate ($PbWO_4$) dust used in the study of EPDM (Ethylene-Propylene-Diene Monomer) matrix composites produced by three different gamma source (^{155}Eu, ^{137}Cs and ^{60}Co radiation attenuation performance have been investigated and the absorption of gamma rays increasing in the percentage of rubber to increase the performance of the PWO is stated [15]. The head of laminated composites containing Basalt Fiber Reinforced with epoxy resin produced by Kev in energy between 31 and 80 has protective qualities against the values of X and gamma rays indicated that [16]. The work of an Unsaturated Polyester Resin matrix in different proportions in lead monoxide (PbO) and 5 WT.-%nanoclay composite samples produced by participating in ^{192}Ir, ^{137}Cs, and ^{60}Co gamma sources in the measurements with the increase of PBO content, the shielding performance increase, however, it has been stated that composites can be used as an armour material at low energies [17]. Gamma-rays reduce to 8 different polymers (polyamide (PA-6), polyacrylonitrile (PAN) polivinilidendeklorur (PVDC), polyaniline (PANI), polietileneterftalat (PET), polifenile sulfide (PPS), poliprol (PP) and polyethylene (PPR)) for high-resolution HPGe detector with the help of the 81 keV – 1333 keV in the energy range examined using different radioactive sources. They observed that the linear reduction coefficients of all polymers decrease rapidly at low energies [18]. Kacal et al. have studied the gamma-ray reduction properties of Zn-reinforced polymer composites. Using the HPGe detector, they measured the mass reduction coefficients of composites in the energy December of 59.5 keV – 1408.0 keV. As the addition of Zn increases, they have observed that the property of armouring increases [19]. The gamma-ray shielding properties of polymer composites doped in CdTe at different rates (5%, 10%, 15% and 20%) using an HPGe detector have been investigated theoretically and experimentally. As the contribution increases, it has been determined that there is an increase in protection efficiency [20].

In this study, both medical and protective technical textiles, which are very important for the health sector in terms of the functional properties of technical textiles, have been studied both radiation-protective and antibacterial properties have been given to woven fabrics.

MATERIALS AND METHODS

Material

In this study, cotton woven fabric (97% cotton, 3% elastane) with a weight of 247 g/m^2, weft density of 55 wire/cm, a warp density of 33 wire/cm; cotton/polyester woven fabric (59% cotton, 39% polyester, 2% elastane) with a weight of 236 g/m^2, weft density 34 wire/cm, warp density 60 wire/cm were used.

Antibacterial properties of the fabrics were investigated by applying nanosilver in 20–25 nm size. In recent years, antibacterial textile products with silver applied have been used intensively. The most important reasons for this are that bacteria are prevented from multiplying by passing through the cell membrane, it is an odour remover, the use of a certain amount does not harm the human body, and it is effective on more than 650 microorganisms that cause disease [21]. It is used in many areas such as socks, underwear, sheets, sofa upholstery, antibacterial food packages, wounds and burns [2, 22, 23].

Staphylococcus aureus (ATCC 6538), which is frequently encountered in hospitals and causes infection, and *Escherichia coli* (ATCC 35218) which is in intense contact with textile surfaces, were used for antibacterial tests [24, 25].

Tubicoat CRO was used as a coating chemical with tungsten and barium sulfate, which have radiation shielding properties, to give the fabrics radiation shielding properties [26, 27].

Method

The impregnation method, which is an application process in a short time and a short liquor ratio, was used in the treatment bath for cotton and cotton/polyester fabrics. With this method, the solution obtained by mixing 1% nano silver with distilled water on cotton and cotton/polyester fabrics in Ataç brand FY 350 model foulard was poured between two bar pressure cylinders and impregnated [28]. The fabrics were dried at 80°C for 15 minutes and fixed at 100°C for 3 minutes.

A homogeneous coating material was obtained by mixing Tubicoat CRO, which is a coating chemical, with barium sulfate and tungsten separately. 60% tubicoat, 40% barium sulfate and 40% tungsten were used in the study. The coating material was applied to the fabrics using a squeegee. After the coating process, the drying and fixation processes of the fabrics were carried out in the fixing machine. The barium sulfate-coated fabric was dried at 80°C for 15 minutes, the tungsten-coated fabric was dried at 80°C for 10 minutes, and both fabrics were fixed at 100°C for 3 minutes.

To examine the radiation shielding properties of fabrics, ^{137}Cs source, which is widely used in medical applications, has been used. By using the gamma spectrometer measurement system ORTEC brand, GEM50P4-83 model high purity coaxial Ge detector, 600 seconds of radiation shielding was applied to the fabrics. The ^{137}Cs source has an energy of 661.6 keV and an abundance of 85% with a half-life of 11022 days. The gamma spectrometer system consists of a detector, a preamplifier, a spectroscopy amplifier, an ADC system that converts analogue counts into electronic signals, and a multi-channel analyzer (MCA) [29].

AATCC 147 antibacterial test method, which is an easy and fast method, was applied to examine the antibacterial properties of woven fabrics qualitatively. In this method, bacteria were vaccinated and the fabrics were placed in petri dishes by making contact with the fabric, and the antibacterial properties of the samples, which were kept in an oven at 37°C for 24 hours, were determined according to the formation of the inhibition area [30].

RESEARCH FINDINGS

The fabrics were classified as no treatment applied, only nanosilver applied, only tungsten and barium sulfate applied, and nanosilver and tungsten and barium sulfate applied fabrics.

Radiation shielding

In table 1, the number of particles per second and radiation shielding rates (%) of the fabrics against the ^{137}Cs source with 662 keV energy are given.

$$\text{Radiation Shielding (\%)} = [(I_0 - I) / I_0] \cdot 100 \quad (1)$$

where I_0 is the intensity of the incident photons on the fabric before they are absorbed and I – intensity of photons absorbed through the fabric.

The radiation shielding percentage of the fabrics was found using the formula given in equation 1.

When the radiation shielding values were examined, it was seen that tungsten and barium sulfate gave the fabrics radiation shielding properties, while nano silver reduced the radiation shielding properties of the fabrics. It has been observed that tungsten-treated cotton fabric has better radiation shielding properties than barium sulphate-treated cotton fabric and barium sulfate-treated cotton polyester fabric has better radiation shielding properties than tungsten-treated cotton polyester fabric.

Table 1

ENERGY AND RADIATION SHIELDING VALUES OF FABRICS AGAINST ^{137}CS SOURCE

Samples	Number of incoming particles per second	Radiation shielding (%)
The Source Itself	168510±413	
Cotton	156194±397	7.3
Cotton-Nano silver	165191±408	1.9
Cotton-Barium Sulphate	151571±391	10
Cotton-Nano silver-Barium Sulphate	153143±393	9.1
Cotton-Tungsten	149812±389	11
Cotton-Nano silver-Tungsten	155194±396	7.9
Cotton/Polyester	155290±396	7.8
Cotton/Polyester-Nano silver	165324±408	1.8
Cotton/Polyester-Barium Sulphate	142279±379	15
Cotton/Polyester-Nano silver-Barium Sulphate	156186±397	7.3
Cotton/Polyester-Tungsten	146518±384	13
Cotton/Polyester-Nano silver-Tungsten	152216±392	9.6

Antibacterial test

The antibacterial activities of cotton and cotton/polyester woven fabrics, with the sample removed, against *S. aureus* and *E. coli* bacteria according to the AATCC 147 Antibacterial test method results are shown in figures 1–4.

It was observed that an inhibition area was formed in all fabrics on which nanosilver was applied, and these fabrics gained antibacterial properties against *E. coli* and *S. aureus* bacteria. Bacterial growth was observed on the surface of some of the coated fabrics. The fabrics were classified among themselves and compared with each other and rradiation-shieldingfabrics with antibacterial properties were obtained.

CONCLUSION

In this study, nano silver with antibacterial properties was applied to cotton and cotton/polyester woven fabrics by impregnation method. Tungsten and barium sulfate, which have radiation protection properties, are coated on fabrics using a squeegee. It has been observed that cotton/polyester fabrics generally have better radiation shielding properties than cotton fabrics against ^{137}Cs source emitting γ radiation. When the radiation shielding values were examined, it was seen that tungsten and barium sulfate gave the fabrics radiation shielding properties, while nano silver reduced the radiation shielding properties of the

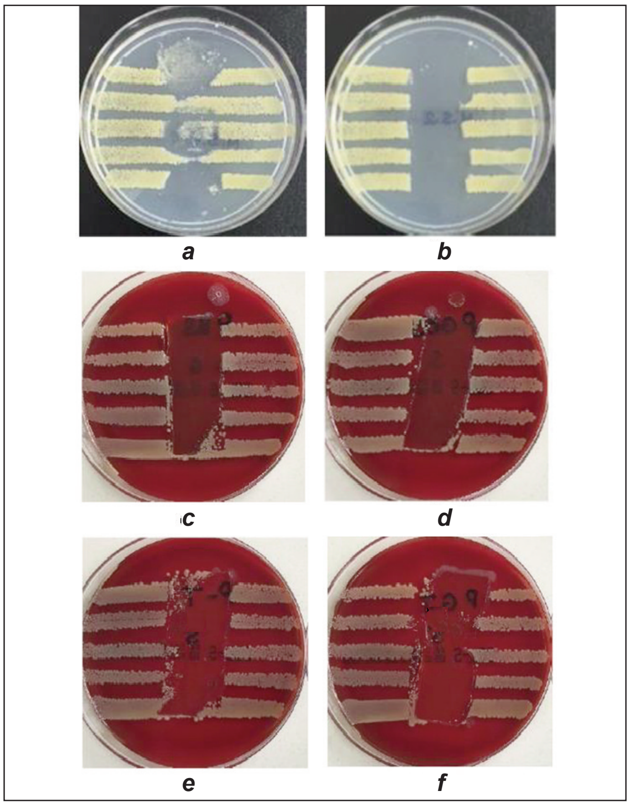

Fig. 1. Antibacterial activities against *S. aureus* bacteria of: *a* – untreated; *b* – nanosilver treated; *c* – barium sulfate treated; *d* – barium sulfate-nano silver treated; *e* – tungsten treated; *f* – tungsten-nano silver treated cotton fabric

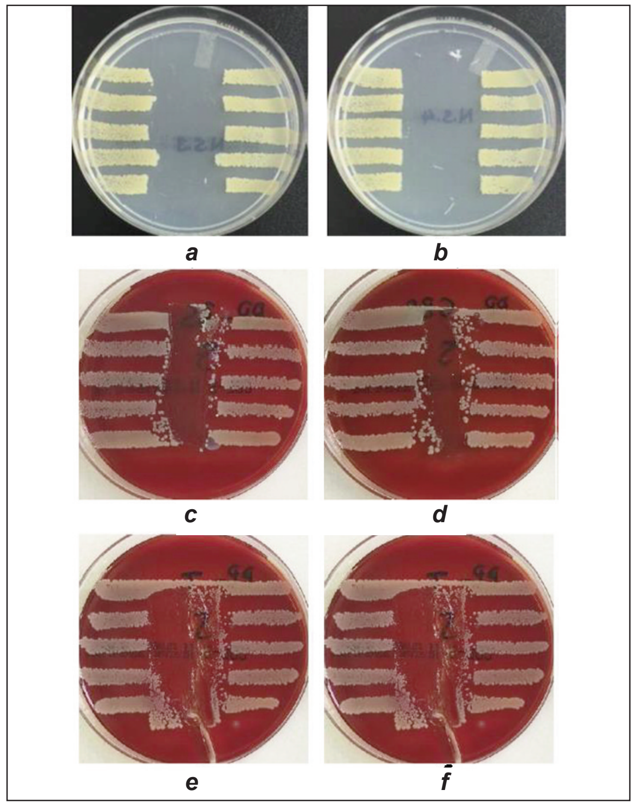

Fig. 2. Antibacterial activities against *E.coli* bacteria of: *a* – untreated; *b* – nanosilver treated; *c* – barium sulfate treated; *d* – barium sulfate-nano silver treated; *e* – tungsten treated; *f* – tungsten-nano silver treated cotton fabric

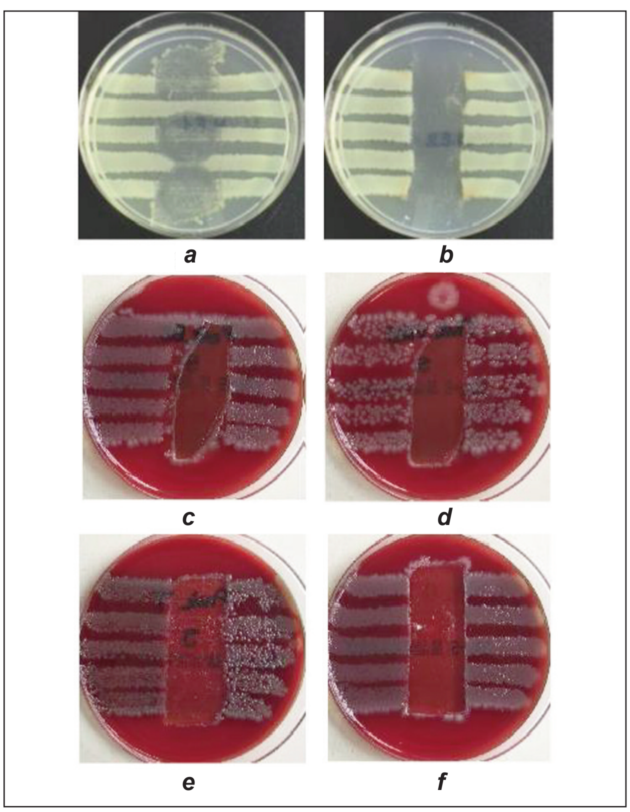

Fig. 3. Antibacterial activities against *S. aureus* bacteria of: *a* – untreated; *b* – nanosilver treated; *c* – barium sulfate treated; *d* – barium sulfate-nano silver treated; *e* – tungsten treated; *f* – tungsten-nano silver treated cotton/polyester fabric

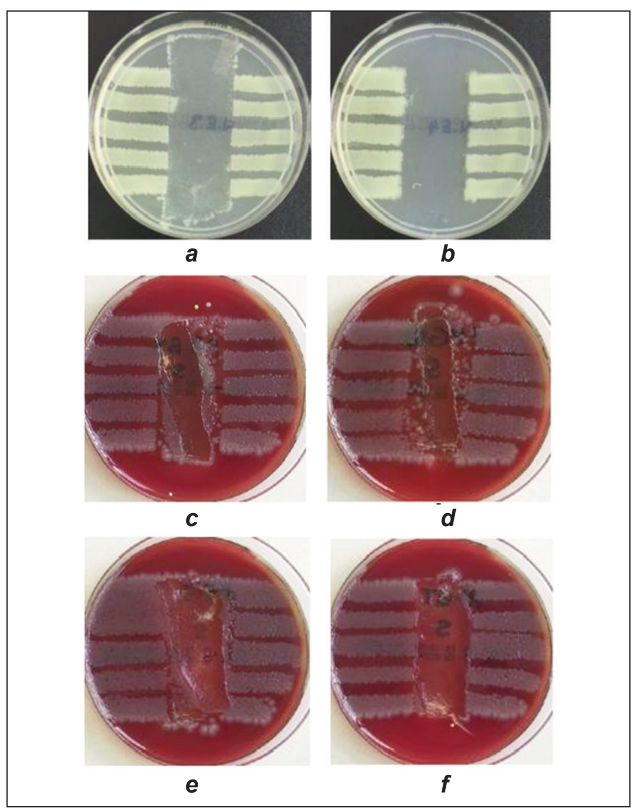

Fig. 4. Antibacterial activities against *E.coli* bacteria of: *a* – untreated; *b* – nanosilver treated; *c* – barium sulfate treated; *d* – barium sulfate-nano silver treated; *e* – tungsten treated; *f* – tungsten-nano silver treated cotton/polyester fabric

fabrics. Bacterial growth was observed on the surface of some of the coated fabrics that were not coated with nanosilver. It would be more appropriate to prefer fabrics with tungsten and barium sulfate applied as nano silver coating material to obtain a radiation-protective and antibacterial fabric.

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