# Topic № 1
# FIBRES AND YARNS; CHEMICAL TECHNOLOGIES; NANOTECHNOLOGIES

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*Industry of High Molecular Substances. Rubber industry. Plastic industry.*

Youth review: Eco collection from the Fashion department of SWU Neofit Rilski


Youth review: Eco collection from the Fashion department of SWU Neofit Rilski

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# INNOVATIVE ANTIBACTERIAL AND ANTICANCER ELECTROSPUN NON-WOVEN TEXTILE FROM CHITOSAN SCHIFF BASE AND POLYLACTIDE AND ITS COMPLEXES WITH $Cu^{2+}$ AND $Fe^{3+}$

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**Introduction** Chitosan (Ch) is biocompatible, biodegradable and non-toxic natural polymer that possess beneficial biological properties - antibacterial, antioxidant and anticancer. In addition, 8-hydroxyquinoline (8Q) and its derivatives have been reported to exert several favorable activities - antibacterial, antifungal, anticancer, antiviral and antioxidant. The chelating ability of these compounds towards biologically significant transition metal ions ($Cu^{2+}$, $Fe^{2+}$, $Fe^{3+}$, etc.) has an impact on their biological activity. The purpose of this work was to study the possibility of preparing innovative electrospun non-woven textile containing Schiff base derivative (Ch-8Q) of Ch and 8-hydroxyquinoline-2-carboxaldehyde or its complexes with $Cu^{2+}$ or $Fe^{3+}$, as well as to investigate the influence of the fiber composition on the antibacterial and anticancer activities of the materials.

**Experimental part** Ch-8Q was synthesized as described earlier [1]. Custom-made electro-spinning set-up was utilized. $Cu^{2+}$ or $Fe^{3+}$ complexes of electrospun mats were obtained by the procedure described in our previous report [1]. The morphology of the electrospun materials was examined by scanning electron microscopy. The antibacterial activity of the obtained materials was evaluated using the viable cell-counting method. The anticancer activity was assessed by the MTT assay.

**Results** and Discussion Innovative non-woven textile from poly(L-lactide-co-D,L-lactide) (PLA) and Ch-8Q was successfully fabricated by one-pot electrospinning of their blend solution. The $Cu^{2+}$ and $Fe^{3+}$ complexes of the obtained textile were also prepared. The formation of complexes was proven by using scanning electron microscopy, attenuated total reflection Fourier-transform infrared spectroscopy and X-ray photoelectron spectroscopy. The performed microbiological test showed that Ch-8Q/PLA mats and their complexes exhibited good antibacterial efficacy against the pathogenic bacteria S. aureus. Cell viability MTT assay revealed that Ch-8Q-containing materials and their complexes possess good antiproliferative activity and decrease considerably the viability of the HeLa and MCF-7 cancer cells for the different periods of cell incubation. Moreover, the observed cytotoxicity of the electrospun nonwoven textile against cancer cells was greater than that against non-cancer BALB/c 3T3 fibroblasts.

**Conclusion** Thus, the innovative non-woven textile has potential as dressing material in wound treatment, as well as for application in the local therapy of cervical and breast cancer.

**Keywords:** chitosan Schiff base, electrospinning, $Cu^{2+}$ and $Fe^{3+}$ complexes, antibacterial activity, anticancer electrospun non-woven textile

**Acknowledgments:** Financial support from the Bulgarian National Science Fund (Grant KP-06-N39/13/2019) is kindly acknowledged.

[1] Ignatova M., Anastasova I., Manolova N., Rashkov I., Markova N., Kukeva R., Stoyanova R., Georgieva A., Toshkova R., Polymers 14, 5002 (2022)

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# ELECTROSPUN CELLULOSE ACETATE/NANOCLAYS COMPOSITES FOR POLLUTANT REMOVAL

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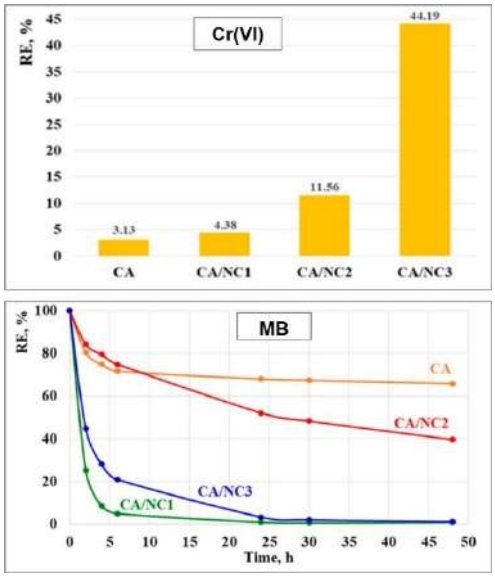
**Introduction** The creation of eco-friendly clay-based composites for pollutant removal by adsorption still remains a challenge. This problem might be successfully solved by the development of electrospun polymer–clay composites. However, the studies on obtaining cellulose acetate (CA)/clay-based composites by electrospinning for pollutant removal are still scarce. In this regard, in the present study a one-step preparation of CA fibers filled with nanoclays was described.

**Experimental** part Cellulose acetate (CA, 30000 g/mol and acetyl content 39.8%) and three different nanoclays (NCs) - hydrophilic bentonite NC1 (Nanomer® PGV), NC2 (Nanomer® 1.28E) and NC3 (Nanomer® 1.31PS) were purchased from Sigma-Aldrich. Acetone (≥ 99.5%), methylene blue B (MB) and potassium dichromate ($K_2Cr_2O_7$) were supplied by Merck. All chemicals were of analytical grade and used without further purification.




**Results** Electrospinning was successfully used for the one-step fabrication of fibrous CA composites filled with NC1, NC2 and NC3 [1]. The addition of nanoclays had no significant effect on the fibers surface morphology. In confirmation of the FT-IR results, TG analyses clearly showed that during the electrospinning process CA and NCs did not react. Based on XRD analysis, it was concluded that the distribution of nanoclay layers in the CA/NCs composites was a mixture of intercalated and exfoliated structures. Considering the potential application for pollutant removal, the adsorption ability of electrospun CA/NC composites in water was evaluated toward Cr(VI) ions and MB as a model pollutant dye, compared with this of electrospun CA.

**Conclusion** Novel CA/nanoclay composites were fabricated by one-pot electrospinning. The adsorption studies clearly showed that the nanoclay type strongly influenced the adsorption capability of composites toward Cr(VI) ions and MB dye. The results suggest that the obtained novel electrospun composites are potential candidates for pollutant removal from water.

**Keywords:** electrospinning; cellulose acetate; nanoclays; Cr(VI) adsorption; methylene blue removal.

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# THE INTERPLAY BETWEEN LIGHT AND TEXTILE MATERIALS FOR HUMAN WELL-BEING AND AESTHETIC PERCEPTION OF THE WORLD

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Textile materials are all around us. They are an irrevocable part of human life because they have a protective function, but in general, the user's choice depends on their aesthetic attitude. That is why fashion draws inspiration for its works from the colour of fabrics or their sparkling whiteness.

The colour of textile materials depends on their structure, the dyes used, the light, and the colour perception of each person. Therefore, this ubiquitous phenomenon combines various scientific fields such as chemistry, physics, physiology and psychology. The colour is a consequence of the interaction of light and the textile material. Fluorescent dyes absorb and emit light, so the impression is of two combined colours. Optical brighteners also fluoresce but emit light that offsets the blue light absorbed by yellowed-white fabrics.

Consumers expect the beauty of textiles to be preserved as long as possible. Sometimes, however, changing the colour and fluorescence of materials can be favourable and serve to track the changes that occur in the person and their environment. The dyeing textile materials with dyes with sensory properties make them suitable for applications in medicine, healthcare, workwear, fashion or wherever challenging design is needed.

Fabrics dyed with photosensitizers, in addition to their beautiful colour, interact with light and oxygen in the air, releasing singlet oxygen and providing antimicrobial protection.

The light also relates to the photosensitive dyes with which the cotton or polyamide fabric is dyed and causes the formation of radicals that initiate photopolymerization. With this treatment, the surface of the fabrics acquires new properties.

Therefore, the light to which life on Earth is due also plays a principal role in textile materials handling and participates in their innovative applications that are unexpected today, which will have wide application in the future.

**Keywords:** textile, colour, light, dyes, medicine, fashion.

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# ELECTROSPUN POLYMER MATERIALS WITH ANTIFUNGAL POTENTIAL

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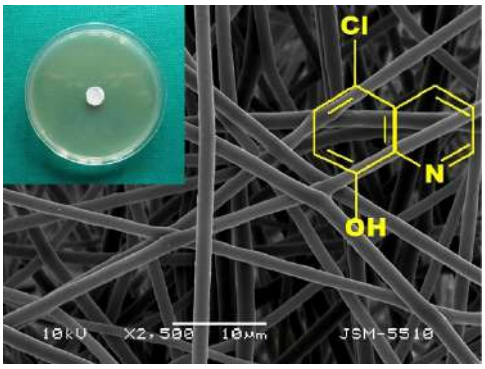
**Introduction** Cutting-edge nanotechnologies such as electrospinning, electrospraying, coaxial electrospinning, centrifugal electrospinning, etc. have attracted special interest in recent years. These innovative methods allow the production of fibrous materials from both synthetic and natural polymers with high specific surface area, high porosity, and various designs for diverse applications. In addition, the incorporation of compounds with biological activity is easily achievable. Moreover, biocontrol agents, able to suppress the development and growth of plant pathogens, could be embedded in the fibrous materials as well. The application of such nanotechnologies for the fabrication of plant protection products is an extremely promising new direction.

**Experimental part** Cellulose acetate (CA, $M_n$ = 30 000 g/mol and DS 39.8%), polyethylene glycol (PEG, $M_r$ = 1 900-2 200 g/mol), poly(L-lactic acid) (PLA, $M_w$ = 259 000 g/mol and $M_w/M_n$ = 1.94), poly(3-hydroxybutyrate) (PHB, $M_w$ = 330 000 g/mol), polyvinylpyrrolidone (PVP, $M_r$ = 24 000 g/mol), 5-chloro-8-hydroxyquinoline (5-Cl8Q), potassium 5-nitro-8-quinolinolate (K5N8Q) and 5-chloro-7-iodo-8-hydroxyquinoline (CQ) were used. Acetone of analytical grade of purity, ethanol (abs. EtOH), N,N-Dimethylformamide (DMF), chloroform and dimethyl sulfoxide (DMSO) were also used.

**Results and Discussion** Fibrous membranes of CA, CA/5-Cl8Q; CA,PEG; CA,PEG/5-Cl8Q, PLLA; PLLA/5-Cl8Q; PLLA/K5N8Q; PHB and PHB/PVP,CQ were obtained by electrospinning/electro-spraying. The morphology of the obtained materials was assessed by SEM and it was found that the fiber diameters decreased with the addition of water-soluble polymer or low molecular weight compounds. The incorporation of the water-soluble polymer resulted in hydrophilization of the materials that was proved by the water contact angle measurements. Biological tests were conducted to evaluate the antifungal potential of the materials against Phaeomoniella chlamydospora and Phaeoacremonium aleophilum. It was found that the mats containing the 8-hydroxyquinoline derivatives possessed strong antifungal activity. The obtained results reveal the potential of the created fibrous materials with antifungal effect as promising candidates for fabrication of plant protection products in agricultural field.




**Conclusion** Polymer membranes based on biodegradable and biocompatible polymers are fabricated by conducting electrospinning or electrospinning with electrospraying. The incorporation of biologically active substances into the membranes imparted to them a significant antifungal effect. The results suggest that the obtained fibrous materials have great potential for application in agriculture. [Nachev, N., Spasova, M., Manolova, N., Rashkov, I., Naydenov, M., Electrospun Polymer Materials with Fungicidal Activity: A Review, Molecules, 27, 1-19 (2022)]

**Keywords:** electrospinning; electrospraying; biopolymers; bioactive substances; antifungal activity;

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# STUDY ON THE APPLICATION OF DBD PLASMA IN FLAME RETARDANT TREATMENT FOR DYED COTTON FABRICS

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**Introduction:** Cotton is one of the most used textile fibres. However, it is a combustible material with a low LOI of 18.4% [1]. Therefore, flame retardant treatment for cotton fabrics, especially durable flame retardant, is an important requirement for many areas of use. Many studies have shown that Pyrovatex CP New (PCN) combining crosslinking agents such as trimethylolmelamine (TMM) or 1,3-dimethylol-4,5-dihydroxyethylene urea (DMDHEU) is a very good choice to create durable flame-retardant cotton fabrics. However, they release formaldehyde, and their mechanical strength is reduced compared with pre-treatments because the crosslinking reaction occurs at high temperature and requires the use of phosphoric acid as a catalyst [2-4]. In our recent studies, a new formaldehyde-free crosslinking agent (Knittex FFRC (K-FFRC)) was used as a replacement for the old one as a solution to reduce the release of free formaldehyde from fabrics [5, 6]. However, our research has shown that when treating cotton fabric with PCN and K-FFRC, for the treated fabric to be fire resistant (LOI > 25), the curing temperature must be greater than 170°C and the time curing must also be longer than 120 seconds. It is this condition that reduces the mechanical strength of cotton fabric [7]. To solve this problem, we pre-treated cotton fabric with DBD plasma for 90 s, plasma treated fabric then treated with PCN and K-FFRC. The results show that the fabric has been pre-treated with plasma, during the flame-retardant treatment it only needs to be cured at 160°C for 90 seconds to have a LOI > 25. To achieve this value, the normal cotton fabric must be cured at 180°C for 120s during flame retardant treatment [7, 8]. This study also shows that too strong plasma treatment conditions (high plasma power, prolonged exposure time) also adversely affect the mechanical performance of cotton fabrics. These studies are all performed on white cotton fabrics after pre-treatment, while functional finishing is usually carried out on dyed fabrics. In dyed cotton, some of the active radicals are usually occupied by dye molecules, so their level of reactivity is different from that of undyed fabrics. Therefore, in this study, DBD plasma was applied on dyed cotton fabrics before they were flame retardant treated with PCN and K-FFRC. The objective of this study was to clarify the effect of DBD plasma treatment on flame retardant treatment for the dyed cotton fabric.

**Experimental** Procedure: Dyed woven cotton fabric with mass of 242/$m^2$ was supplied by NASILKMEX -> APDBD plasma treatment with plasma power of 400 W (1 W/$cm^2$) for 30s -> Flame retardant treatment with PCN and K-FFRC -> Flame retardant dyed cotton fabric -> Washing fabric according to ISO 6330 for 5 cycles

Testing: Flammability of fabric by ASTM D 6413 -2015 and determination of LOI of fabric by ASTM D 2863 -97 befor and after flame-retardant treatment and after washing. Measurment of color of fabric befor and after DBD plasma treatment.

**Result:** The results showed that the DBD plasma pre-treatment improved the efficiency of the flame retardant process for the dyed cotton fabric: the LOI of the fabric before and after washing were both improved compared to samples not pre-treated with DBD plasma. However, compared with the white fabric, the flame-retardant treatment condition for dyed cotton fabric needs to be stronger for the flame retardant treated fabric to have the desired flame-retardant properties. The results also showed that plasma treatment also changed the color of dyed cotton fabrics. The color of the fabric tends to be lighter after plasma treatment.

**Keywords:** Dyed cotton fabric, DBD plasma, Flame retardant, Pyrovatex CP new, Knittex FFRC

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# DEVELOPMENT OF ELECTRICALLY CONDUCTIVE GLASS FIBRE YARN BY ION BEAM COATING TECHNOLOGY FOR THE USE IN INTEGRATED SENSORS

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The aim of the joint project was the realisation of innovative component monitoring sensors (Structural Health Monitoring (SHM)), which are directly integrated into the structure of glass fibre reinforced plastic components (GRP). For the integration of sensory functions into the structure of GRP, highly conductive fibre materials are necessary. The common way is here to use electrically conductive non-glass fibre yarns (e.g. copper cables, conductive polyamide yarns, etc.). But when integrating into GRP, these foreign materials, can significantly weaken the GRP in a variety of ways (e.g. as shown by X. Chen, S. Guo, J. Li, G. Zhang, M. Lu und Y. Shi, „Flexible piezoelectric nanofiber composite membranes as high performace acoustic emission sensors," Sensors and Actuators A: Physical 199 (2013), pp. 372-378, 28. Juni 2013).

Standard glass fibre yarn has no electrically conductive properties. Therefore the project involved the development of electrically conductive glass fibre yarns using the ion beam coating technology of Nanoedge GmbH [1,2]. These coated glass fibre yarns are later used as sensor electrodes in the SHM development of the project partner DITF. They should prevent the formation of negative interface reactions and structural delamination effects in GRP, as they usually appear by using foreign non-glass fibre yarns.

To enable the development of the required electrically conductive glass fibre yarns, conventional glass fibre yarns had to be coated with an electrically conductive coating by Nanoedge GmbH. For this purpose, a winding device (roll-to-roll) was developed to handle the glass fibre yarn, which was later operated in a vacuum chamber. The highly conductive material silver 99.9% was chosen as the preferred coating material which was applied by the low temperature ion beam coating process of Nanoedge GmbH.

One of the main influencing factors to the coating process is the so-called glass fibre sizing material. These sizing layers (mainly silane based substances) are of crucial importance for the flexibility of the inherently very brittle glass fibre yarns. This flexibility is absolutely necessary for subsequent machine processing of fabrics and embroideries, which are the base construction material of GRP. The sizing material also prevents a direct contact between the electrically conductive silver layer and the actual surface of the glass fibre yarn. This leads to poor adhesion of the coating. For this reason, a physical plasma process (integrated into the coating process itself) ,to remove and reactivate the sizing, was also developed by Nanoedge GmbH during the project.

The coating parameters were adjusted iteratively in ongoing exchange with the project partner DITF, that tested the different coated glass fibre yarns by processing them to specific fabrics and embroideries. The coating quality (e.g. uniformity) was continuously assessed using light microscopy and energy dispersive x-ray spectroscopy (EDX).

Before the project started, it was clear that for the construction of a redundantly functioning SHM systems, it is also important that the electrode material (coated glass fibre yarn) has an electrical resistance that is evenly distributed over its length. While the iteration process this was tracked by a four-conductor measurement (according to DIN EN 16812).

Finally different glass fibre yarns with a silver-coating up to 300 nanometres of thickness and a resulting electrical resistance value of up to 200 ohms per meter were selected.

These glass fibre yarns were used by the DITF to build a bending and impact sensor. For this purpose, suitable sensory fabric layers were created using various weaving and embroidery processes. The coated glass fibre yarns serve as sensor electrodes and replace the otherwise commonly used foreign materials (various electrically conductive yarns) in the already known piezoelectric sensor structure of DITF [3,4].

With the fabrication of a SHM demonstrator (GRP-rotor blade of a small wind turbine), it was proved that the electrically conductive glass fibre yarns are fundamentally suitable for the use as electrode material in structure-integrated sensors. After connecting of corresponding power electronics, redundant and evaluable signals can be determined during an impact and bending load on the rotor blade.

***Keywords:*** electrically conductive glass fibre; structural health monitoring; ion beam coating; glass fibre reinforced plastic; piezoelectric sensor

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# COMPARATIVE STUDY OF TWO TYPES OF METAL PARTICLES ON THE PROPERTIES OF TEXTILE MATERIALS

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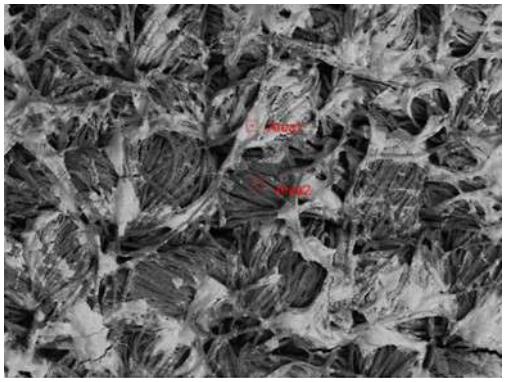
It has been proved that inorganic nanoparticles (NPs) can inactivate the virus due to rupture of the viral envelope by generation of oxidative species. The properties of metal nanoparticles and metal oxides such as titanium dioxide ($TiO_2$), zinc oxide (ZnO), silver (Ag) and copper (Cu) are well known as effective antimicrobial agents. Among other inorganic NPs, $TiO_2$ nanoparticles ($TiO_2$-NPs) and ZnO-NPs have attracted the attention of researchers because they are biocompatible, nontoxic, and relatively inexpensive.

A comparative analysis of the properties of cotton fabric modified with gelatin hydrogel cross-linked with glutaraldehyde and containing ZnO and $TiO_2$ nanoparticles, respectively, was made in this study. Three methods of ZnO and $TiO_2$ synthesis were investigated by varying the components and processing conditions. The *in situ* method for obtaining ZnO and $TiO_2$ nanoparticles separately on the surface of cotton fabric was successfully applied. The composite materials were examined by means of SEM, UVA/VIS/NIR spectrophotometric and antibacterial activity analysis.

Non-identical distribution distribution behavior of the different metal particles was observed in the microscopic studies. $TiO_2$-NPs were impregnated into the hydrogel structure on the cotton fabric and were distributed into small film-forming structures in the cotton fabric and unevenly agglomerated. In the composites with included ZnO nanoparticles, obtained by one of the methods, showed that the spherical particles changed into a flower-like shape, with needle-like ends, indicating that the nucleation of ZnO crystal structures started on the textile surface.



In the UV-spectral analysis, the appearance of new peaks at 877 $cm^{-1}$ to 890 $cm^{-1}$ was observed, confirming the association of the formed $TiO_2$ nanoparticles with the hydroxyl groups in the composites. For the other metal particles, a new absorption peak at 651 $cm^{-1}$ appears due to the attachment of ZnO-NPs. The appearance of new peaks at 720 $cm^{-1}$ to 870 $cm^{-1}$ confirms the formation of tetrahedral coordination of ZnO.

Antibacterial studies show different activity depending on the strain and type of composites. The $TiO_2$-NPs modified samples showed better activity against the Gram-positive and Gram-negative bacteria used compared to the ZnO-NPs modified samples. Biocomposites cotton-gelatin-ZnO NPs or respectively with $TiO_2$nanoparticles can be very effective used in the form of wound dressings.

**Keywords:** *modification, cotton fabric, gelatin, metal nanoparticles*

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# POLYMERIC COMPOSITE ELECTROSPUN NANOFIBERS WITH NANO FILLERS

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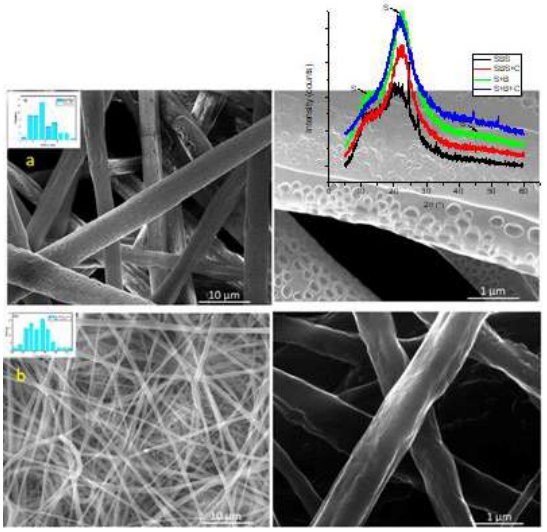
Introduction Electrospinning is one of the processing methods for deriving micro- and nanofibers from polymer solutions and melts by the presence of electrical forces. Electrospun fibrous polymeric composite membranes with a high surface area and high pore density serve in medical and tissue engineering, batteries, catalytic applications, and smart textile products. Carbon nanotube(CNT)/ polymeric composite smart fibers can contribute to health and medical applications i.e., bone reconstruction, where sensing and soft surface are required, the development of fiber and textile structures with enhanced breathability as a delivery tool for drugs and biomolecules to enhance cell recovery.

In this study, CNT- and Fe-based nanofillers were applied to optimize the properties of the polymer matrices in the fiber form and investigate the effects of the nanofillers. The electrospinning was used successfully to fabricate nanofibers of Iron oxide/poly(m-anthranilic acid)/poly(ε-caprolactone) and CNT/polybutadiene (PBu), and poly(styrene–butadiene–styrene) (SBS) composite elastomeric fibers, and they are thermomechanically, and spectroscopically characterized.

Experimental part Dynamic mechanical analyses, X-ray photoelectron spectroscopy, Scanning electron microscopy(HRSEM), Fourier-transform infrared spectroscopy, Raman spectroscopy, and X-ray diffractometry are employed to investigate the mechanism of interaction between nanofiller and polymer matrix. CNT-embedded SBS (Mw ~ 140 k), and PBu (Tg = 95 °C, Mw ~ 200 k)-Polyethylene oxide (PEO, Tg =-67°C, Mw of ~100 k), poly(ε-caprolactone) (PCL, Mw: 80 k) matrices are used.




Results & Discussion The Inclusion of CNTs into SBS decreases the fiber thickness by an order of magnitude, from micro to nanoscale, while a transition from a porous to nonporous and rough morphology is attained (Fig.). HRSEM and energy-dispersive X-ray supported the findings of the thermomechanical analysis, and the mechanism of interaction between CNTs and the SBS tri-block copolymer matrix through the determination of the morphology, pi–pi* interactions, and the crystallinity of the composite fibers. The mechanical properties of CNTs-filled electrospun fibers are improved compared to the original fibers. The semicrystallinity of SBS/PStyr disappears with the inclusion of CNTs of 1.25 wt%, indicating even small quantities of CNTs retard the crystallization process. The inclusion of iron and carboxylic acid-functionalized polyaniline into PCL enhances the electron-donating ability which in turn increases the compound conductivity and may induce reversible redox chemistry, allowing them to be used in electrochemical immunosensors and drug delivery.

Keywords: Electrospun nanofibers,carbon nanotube, poly(styrene–butadiene–styrene), poly(ε-caprolactone)

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# PHOTODYNAMIC ANTIBACTERIAL ACTIVITY OF COTTON FABRIC MODIFIED WITH 1,8-NAPHTALIMIDE DERIVATIEVES

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***Introduction***
Textile materials modification with substances with photodynamic antimicrobial activity is promising current tendency to deal with enhanced microbial resistance. 1,8-naphtalimide fluorophores find application as chemical sensors and for imaging of cells, as anticancer therapeutics and as photosensitizers for photodynamic therapy because they have characteristic photochemical properties and bioactivity.
This study aims to dye cotton fabric with two newly synthesized compounds containing 1,8-naphthalimide derivatives as fluorophores, one of which emits blue fluorescence (NIO) and the other yellow-green fluorescence (NIN), to determine the colourimetric characteristics of the obtained fabrics at different concentrations of the two compounds and their resistance to wet processing, as well as to investigate their photoantimicrobial action.
***Experimental part***
Cotton fabric was dyed by spraying technic with an ethanol solution of two insoluble in water dyes. The obtained samples were named the same as fluorescence compounds NIO and NIN. The dye concentrations were 0.1%; 0.2%; 0.3% and 0.4% of the weight of fabric. The colourfastness to washing was evaluated with BDS EN ISO 105-C06:2010 test standard. The release of singlet oxygen was measured from textile samples immersed in KJ solution under visible or daylight irradiation. The antibacterial properties of textile samples were evaluated against Gram-positive Bacillus cereus and Gram-negative Pseudomonas aeruginosa model bacterial strains.
***Results and Discussion***
The colour difference delta E of the obtained textile samples were analysed. Delta E equalization was observed between their faces and backs after fabric washing. The colour parameters a* and b* characterized fabric NIO as white with a blue hue, while fabric NIN is yellow-green. More singlet oxygen was exuded from NIN than from NIO. The fabric`s antibacterial activities are more pronounced against Gram-positive bacteria. NIO is more active in the dark, while NIN is more active under visible light irradiation.
***Conclusion,***
Spray dyeing with ethanol-soluble compounds is a quick, easy and reliable method of depositing water-insoluble substances on fabric. An optimal photosensitizer concentration achieves good colour characteristics and photodynamic antimicrobial activity. The antibacterial textile properties depend on the type of the applied photosensitizer and the type of light.

**Keywords:** antimicrobial textile, spray dyeing in organic solvent, photodynamic therapy.

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# APPLICATION OF INNOVATIVE TEXTILE COMPOSITES FOR SORPTION OF PETROLEUM AND PETROLEUM PRODUCTS

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Pollution of the hydrosphere by oil and/or petroleum products leads to profound, in most cases irreversible, changes in ecosystems chemical, physical and microbiological properties. These facts determine the relevance of studies related to the development of methods and means for the eradication of spills of petroleum and petroleum products.

Natural fibrous organic materials, such as cotton fiber, corn stalk and non-woven fabric (wool), are affordable and environmentally friendly. Natural sorbents provide rapid removal of oil through the pore filling mechanism, but the sorption capacity is limited by their volume. New materials and technologies are needed to clean oil spills quickly and efficiently.

In the present study, composite textile materials modified with crosslinked chitosan (sample CB) and containing nanoparticles of zinc oxide specimen (sample CBZ) were obtained. Their sorption properties against petroleum, diesel fuel and SN 150 oil were studied, as well as the possibility of their regeneration and subsequent use. The results showed that the addition of Zn ions to the surface of the composites, improves their sorption capacity. Sample CBZ was found to exhibit a higher sorption capacity than sample CB, relative to all sorbates used. The best sorption capacity, sample CBZ, is 2.2 g/g for crude oil and the lowest for diesel (1 g/g).

In the examination of the regeneration capability of textile composites, it was found that they could be successfully regenerated and reused without any significant change in their sorption capacity. This makes the materials we obtain extremely effective, as they can be used many times and at the same time allow the separation and utilization of the crude oil and petroleum products sorbed by them.

**Keywords:** composite textile materials, sorption capacity, regeneration.

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# ELECTROSPUN BIOPOLYMER MATERIALS LOADED WITH PHENOLIC COMPOUND WITH HIGH ANTIOXYDANT ACTIVITY

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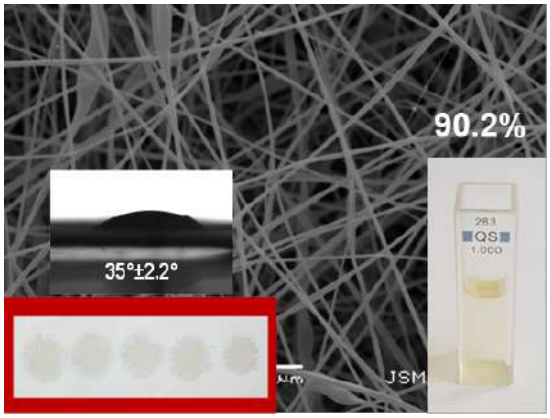
***Introduction***
Electrospinning is relatively easy, efficient method enabling the production of fibrous materials with diverse morphology, large specific surface area and porous structure, thus makes the electrospun mats perspective candidates for many applications such as scaffolds for tissue engineering and cell culture, wound dressings, drug delivery, cosmetics, etc. From ancient times, mankind had intense interest in different therapeutic strategies based on plant-derived medications for the treatment and prevention of some major diseases. Rosmarinic acid (RA), is a polyphenol constituent of many culinary herbs. RA possesses powerful antimicrobial, anti-inflammatory, antioxidant and even anti-aging effects. Encapsulation of plant extracts, through electrospinning, can accelerate their remedial potential. This process increases the therapeutic potential by improving bioavailability and maintains a steady concentration of bioactive compound to the target area. The aim of the present study was to prepare and to characterize novel fibrous materials based on a biocompatible polymer containing a phenolic compound - rosmarinic acid (RA) by electrospinning.

***Results and Discussion***
The optimal process conditions for the fabrication of defect-free fibers based on cellulose acetate and RA were found. The obtained fibrous materials were fully characterized by scanning electron microscopy (SEM), Fourier transform infrared spectroscopy (FTIR), X-ray diffraction analysis (XRD) and water contact angle measurements. It was found that the incorporation of the phenolic compound resulted in reduction of the fiber diameters and the measured water contact angle values. In addition, it was found that the bio-based fibers containing the RA showed high antioxidant activity.




***Conclusion***
RA-containing fibrous mats exhibited high antioxidant activity as estimated by DPPH free radical scavenging method. Therefore, the created innovative mats might have a practical use for wound healing applications, as well as in food industry.

**Keywords:** rosmarinic acid; biopolymer; electrospinning; high antioxidant activity; wound dressings;

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# PROCESSING OF WASTE COTTON TO GLUCOSE AND VALUABLE CHEMICALS (HYDROXYMETHYLFURFURAL)

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***Introduction***

Due to the limitations of the possibilities of using fossil resources, ways to produce biofuels and biochemicals from biomass are being investigated. One of the top chemicals with high added value is 5-hydroxymethylfurfural (HMF). It is an important target product as it represents a potential substitute for petroleum-based monomers of various polymers and can be used as a starting material for biofuels. HMF can be produced by dehydration of C6 carbohydrates, among which glucose is the most suitable. It can be obtained from waste cotton textiles. The conversion of glucose to HMF is an important challenge. Biphasic systems are promising media for the conversion of glucose to HMF: high yields are obtained (THF/water/NaCl system). The catalyst also plays a key role in the rate of dehydration. Systems in which Lewis and Brønsted acidities are combined are used. Heterogeneous catalysts are preferred and can be obtained from activated carbon (AC) after modification. ACs can be prepared from waste biomass. Biomass-based ACs are becoming increasingly attractive because they can be derived from lignocellulosic second-generation biomass.

The aim was to investigate the effectiveness of prepared heterogeneous AC catalysts in the conversion of glucose to HMF in biphasic water: THF system. The reaction conditions were studied to find optimal reaction time.

***Experimental part***

A cotton textile sample was pretreated simultaneously mechanically, hydrothermally and by ultrasound. Two types of enzymes were used for enzymatic hydrolysis of the studied samples for glucose production. Glucose is transformed to HMF in a water: tetrahydrofuran (THF) biphasic system where the reaction is catalysed by AC obtained from almond shells i modified by zinc impregnation (Lewis acid sites) and sulfuric acid treatment (Brønsted acid sites). Experiments with different durations were conducted to find the optimal reaction time.

***Results and Discussion***

Glucose was obtained from a waste cotton textile sample. AC catalysts prepared were characterized with multiple characterization techniques to verify their properties. Glucose is transformed to HMF in a water:THF biphasic system and the reaction is catalyzed by the catalysts obtained. It was found that the highest yield of HMF was acquired at a reaction time of 8 h.

***Conclusion***

Glucose, maximum yield 16 % from a waste cotton textile was obtained. Lignocellulosic waste material, almond shells, was used as a raw material for the preparation of activated carbon-based catalysts. The prepared novel catalysts were characterized and used in water: THF biphasic system to convert glucose to HMF. The highest HMF yield 76% was obtained.

**Keywords:** waste cotton textiles, glucose, HMF production

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# TEXTILE-HYDROGEL COMPOSITE MATERIAL-ANTI-INFLAMMATORY AGENT, WITH POTENTIAL APPLICATION AS A WOUND DRESSING

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***Introduction***

Wound dressings are an important segment of the medical and pharmaceutical market. Today, the dressing is not only expected to cover the wound and protect it, but also to actively support the healing process. This process is often delayed as a result of complications from bacterial infections and inflammatory reactions. It is therefore necessary to develop new wound dressings that have antimicrobial properties containing an anti-inflammatory agent to contribute to rapid wound. The aim of the study is to obtain and characterize new composite materials-hydrogel-cotton fabric with potential application as wound dressings, releasing an anti-inflammatory biologically active substance.

***Experimental part***

The 100% cotton fabric is dyed with modified reactive dye. The dyed fabric was impregnated with a solution of acrylamide and a crosslinking agent in the presence of MDEA, which is a co-initiator of photopolymerization. The resulting materials were characterized by determining the gel fraction, the degree of gel swelling in distilled water and in buffer solutions, the composites were examined using an optical microscope. In vitro experiments were performed to monitor the loading and release of diclofenac sodium from the samples in phosphate buffer pH=7.4 at 37°C, which was monitored using UV-vis spectroscopy.

***Results and Discussion***

The surface morphology of the composites was examined with an optical microscope, and it was found that the hydrogel covered the cotton fibers. Treatment of the materials with different amounts of basic monomer and crosslinker resulted in materials with different hydrogel structure, which in turn plays an important role in the loading and release of anti-inflammatory agent. The swelling of the materials in water and in buffer solutions is greater in those crosslinked with a smaller amount of crosslinker, which forms a thin layer of hydrogel on the surface of the fibres. The composite materials that absorb the greatest amount of liquids also absorb and release the least amount of diclofenac sodium, since it is water-insoluble.

***Conclusion***

Novel composite materials releasing an anti-inflammatory agent (diclofenac sodium) with potential application as wound dressings have been prepared. The hydrogel was found to be attached both on the surface and inside the cotton fabrics. The composite materials show that they can be used as carriers of biologically active substance. Diclofenac sodium was found to be released over 24 hours in phosphate buffer pH 7,4 at 37 °C.

**Keywords:** Wound dressings, diclofenac sodium, cotton fabric, hydrogels, controlled drug release

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