

Izvirni znanstveni članek *Original Scientific Paper*Lidija Gomboc Szabó¹, Renate Lützkendorf¹, Marina Weiß-Quasendorf¹, Majda Sfligoj Smole², Zoran Stjepanović²¹Thüringisches Institut für Textil- und Kunststoff-Forschung e.V., Abteilungsleiter Textil- und Werkstoff-Forschung, Breitscheidstraße 97, 07407 Rudolstadt, Germany²Univerza v Mariboru, Fakulteta za strojništvo, Oddelek za tekstilne materiale in oblikovanje, Smetanova 17, 2000 Maribor/University of Maribor, Faculty of Mechanical Engineering, Department for Textile Materials and Design, Smetanova 17, SI-2000 Maribor, Slovenia**Analiza vpliva hitrosti preizkušanja na obnašanje tehničnih filamentnih prej pri nateznem preizkusu***Influence Analysis of Test Speed on Technical Filament Yarns Behaviour in Tensile Test*

V prispevku sta predstavljena dva različna načina nateznega preizkušanja linijskih tekstilij: natezno preizkušanje pri standardnih pogojih preizkušanja s standardnim dinamometrom in natezno preizkušanje pri velikih hitrostih. Raziskovali smo obnašanje treh tipov tehničnih filamentnih prej: dveh poliamidnih (PA 6.6 in PA 4.6) in polietilenteraftalatnega (PET) multifilamenta visokih trdnosti.

Na podlagi rezultatov raziskave sklepamo, da deformacijska hitrost ($\dot{\epsilon}$) pri vseh treh preizkuševalnih prejah vpliva na natezne lastnosti materiala. To pomeni, da se mehanskih lastnosti in nateznega obnašanja prej pri velikih hitrostih obremenitve ne da pojasnjevati zgolj s podatki, dobljenimi pri standardnih pogojih preizkušanja, temveč je treba uvesti ustrezno metodo z višjimi hitrostmi preizkušanja.

Ključne besede: tehnične multifilamentne preje, konvencionalni natezni preizkus, visokohitrostno preizkušanje, standardni dinamometer, servohidravlična natezna naprava

Two different ways of tensile testing of liner textiles, namely the tensile testing under standard conditions with a standard dynamometer and high-speed tensile testing are presented in the article. Within this research, we studied the behaviour of three types of high-tenacity multifilament technical filament yarns, i.e. two polyamide yarns (PA 6.6 and PA 4.6) and polyethylene terephthalate (PET).

Based on the results of the research, we can conclude that the strain rate ($\dot{\epsilon}$) in all three tested yarns affected the material tensile properties. This means that the mechanical properties and tensile behaviour of technical yarns cannot be explained only with the data obtained under standard test conditions. For better understanding of the behaviour of technical yarns, it is necessary to introduce an appropriate method with high-speed testing.

Keywords: technical multifilament yarns, conventional tensile test, high speed tensile test, standard tensile testing machine, servo-hydraulic tensile testing machine

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Namen raziskave je bil proučiti vpliv surovinske sestave vlaken in klimatskih razmer na učinkovitost sodobne protimikrobne sol-gel apreture na podlagi dimetil-tetradecil-[3-(trimetoksisilil)-propil] amonijevega klorida (Si-QAC), nanesene na bombažno, svileno in volneno tkanino, ki se največkrat uporabljajo pri konserviranju-restavriranju zgodovinskih tekstilij. Sredstvo Si-QAC je bilo naneseno po izčrpalnem postopku pri koncentraciji sola, enaki 0,5 odstotka na maso blaga. Prisotnost apreture na površini tkanin je bila potrjena z rentgensko fotoelektronsko spektroskopijo. Protimikrobna aktivnost sredstva je bila ocenjena na podlagi določitve stopnje adsorpcije gliv iz zraka in hitrosti njihovega razširjanja po vlaknih v času hranjenja tkanin v štirih prostorih pri različnih naravnih klimatskih razmerah. Iz rezultatov je bilo razvidno, da sredstvo Si-QAC pri uporabljeni koncentraciji ni zagotovilo biocidne zaščite proučevanih tkanin. Njegova prisotnost je zavrla rast gliv na bombažni tkanini, kar pa ni bilo opaziti pri svileni in volneni tkanini. Stopnja rasti gliv na tkaninah je bila neposredno odvisna tudi od nihanja temperature, relativne vlažnosti in onesnaženosti zraka v prostorih. Nanos apreture je povečal hidrofobnost in zmanjšal elektrostatičnost vseh proučevanih tkanin, kar je pozitivna lastnost apreture.

Ključne besede: protimikrobna zaščita, naravna vlakna, konserviranje-restavriranje, vpliv surovinske sestave vlaken, vpliv klimatskih razmer, omočljivost, elektrostatičnost

The aim of the research was to investigate the influence of fibre composition and the climatic conditions on the effectiveness of contemporary antimicrobial sol-gel finishing based on dimethyl-tetradecyl-(3-trimethoxysilylpropyl) ammonium chloride (Si-QAC). The agent was applied to cotton, silk and wool fabrics, which are mostly used in the conservation and restoration procedures on historical textiles. The agent was applied with the exhaustion

method at the sol concentration of 0.5% of weight of fabric. The presence of coating on the fabric surface was confirmed with the X-ray photoelectron spectroscopy. The antimicrobial activity of the agent was estimated by determining the rate of adsorption of fungi from the air and by determining the velocity of their distribution on fibres during the storage in four different natural climatic conditions. The results showed that the agent Si-QAC at the used concentration did not provide the biocidal protection of the studied fabrics. The presence of the agent inhibited the rate of adsorption of fungi from the air only in the cotton fabric, whereas this phenomenon was not obtained for the woollen and silk fabrics. The rate of growth of fungi on the fabrics was directly influenced by the fluctuations in temperature and relative humidity, as well as the air pollution in the space of storage. The application of the agent increased hydrophobicity and decreased the electrostatic properties of the studied fabric, which is a positive feature of the coating.

Keywords: antimicrobial protection, natural fibres, conservation-restoration, influence of fibre composition, influence of climatic conditions, wettability, electrostatic properties.

Izvirni znanstveni članek *Original Scientific Paper*

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Uporaba mikrokrmilnika z lastno izdelanim tiskanem vezjem za aplikacije v tekstilstvu

Use of Microcontroller with Custom Made Printed Circuit Board for Textile Applications

V današnjem času je elektronika postala del oblačila, v vgrajenimi mikrokrmilniki v povezavi z različnimi senzori (npr. temperaturnimi ali svetlobnimi) in LED-svetili omogoča nešteto kombinacij za njihovo uporabo, tako v zaščitne kot dekorativne namene. Pralni mikrokrmilniki, kar je njihova velika prednost, omogočajo različne povezave med LED-elementi in jih lahko programiramo za poljubno uporabo, kar je za uporabo v tekstilne namene izjemno pomembno. Na trgu obstajajo različni mikrokrmilniki (npr. ATMEL Atmega, ATtiny itd.), ki so uporabljeni pri izdelkih nosljive elektronike tipa Lilypad Arduino. Z uporabo navedenih mikrokrmilnikov je mogoče razviti lastno aplikacijo tiskanega vezja, ki je poljubne oblike in cenovno veliko ugodnejša. V prispevku je predstavljena izdelava tiskanega vezja ter programa za različno delovanje LED-svetil (postopno ali sočasno prižiganje in ugašanje LED-svetil). Končni izdelek

je opozorilno-dekorativna puščica, katere obliko določajo LED-svetila, ki se različno prižigajo. Raziskava je pokazala, da lahko znanje s področja tekstilstva, kemije, elektronike in programiranja pripomore k izdelavi kakovostne aplikacije, ki poleg tekstilne komponente vključuje tudi elemente elektronike.

Ključne besede: mikrokrmilniki, tiskana vezja, nosljiva elektronika, LED-svetila

Electronics has become a part of clothes with integrated microcontrollers in the combination with various sensors (temperature or light sensors) and LED lights, enabling numerous combinations of their usage, for protection or decoration, respectively.

Washable microcontrollers – the washability being their great advantage, enable various combinations between LED elements and can be programmed for different usage, the latter being of extreme importance for textile purposes. On the market, different microcontrollers (ATMEL Atmega, ATtiny etc) are used in the products of wearable electronics – Lilypad Arduino. Using these microcontrollers enables the development of new applications of a printed circuit board of optional size and more acceptable price.

In our contribution, a custom made printed circuit board and a program for a different action of LED lights is represented (LED lights gradually or simultaneously turning on and off). The final product of the research is a decorative safety arrow the shape of which is defined with LED lights which are differently turning on and off. The research showed that the knowledge from different fields, e.g. textiles, chemistry, electronics and programming, can lead to the creation of a textile application with electronics elements.

Keywords: microcontroller, printed circuit boards, wearable electronics, LED lights.

Pregledni znanstveni članek *Scientific Review*

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Naravno obnovljiva rastlinska tekstilna vlakna *Sustainable Plant Textile Fibres*

Zaradi čedalje globlje ekološke ozaveščenosti in okoljevarstvenih zahtev obravnavamo v sodobnem času izdelavo, uporabo in odstranjevanje materialov veliko bolj kritično. Naravna celulozna vlakna so v tem pogledu izkazala svojo kakovost in popolnoma izpolnila vse ekološke kriterije. Naravna celulozna vlakna uporabljamo za tekstilne in tekstilnotehnične namene. To so vlakna iz ličja stebel, ki tvorijo vlaknate snopiče v notranjem

ličju stebel dvokaličnic, in listna vlakna, ki tečejo po dolžini listov enokaličnic, ter semenska vlakna in vlakna iz plodov. Lan, konopljo, juto, ramijo, sisal ter kokos uporabljamo predvsem za tehnične namene.

V zadnjem času pa izjemno narašča zanimanje za obnovljive surovinske vire tudi na področju vlaken. V ospredju so vlakna rastlinskega izvora. Pri iskanju novih surovinskih virov se proučujejo številne rastline, ki ne spadajo med tradicionalne vire vlaken, da bi iz njihovih stebel ali listov izolirali vlakna uporabnih lastnosti.

Pri izolaciji vlaken pridobimo tehnična vlakna, kar pomeni, da so celulozna vlakna večcelične strukture, pri katerih so posamezne celice vezane v snopiče. Poleg konvencionalnih načinov izolacije vlaken se uporabljajo tudi številni sodobni postopki, kot so biotehnološki z uporabo encimov, itd. Način, kako vlakna izoliramo, vpliva na površinsko morfologijo vlaken.

V prispevku so predstavljena nekatera vlakna, ki jih pridobivamo iz kmetijskih odpadkov, kot so slama žitaric, listi ananasa, sladkorni trs, hmeljeva stebela, kinoa, vlakna iz različnih trav itd. Ključne besede: rastlinska vlakna, naravno obnovljiva vlakna, ne-tradicionalna vlakna

The manufacture, use and removal of traditional materials are now considered more critical due to increasing environmental consciousness and the demands of legislative authorities. Natural cellulose fibres have successfully proven their qualities when also taking into account an ecological view of fibre materials. Different cellulose fibres can be used for textile and technical applications, e.g. the bast or stem fibres which form fibrous bundles in the inner bark (phloem or bast) of the stems of dicotyledenous plants, the leaf fibres which run lengthwise through the leaves of monocotyledenous plants, and the fibres of seeds and fruits. Flax, hemp, jute, ramie, sisal and coir are mainly used for technical purposes.

Recently, the interest in renewable resources for fibres particularly of plant origin has increased. Therefore, several non-traditional plants are being studied with the aim to isolate fibres from plant leaves or stems.

A review of some untraditional fibres is given in the paper. Technical fibres are mainly obtained with fibre isolation, which means that cellulose fibres are multicellular structures with individual cells bound into fibre bundles. Different retting processes can be performed in both acid and alkaline mediums, respectively, and with an enzymatic treatment. The used procedure influences the fibre surface morphology.

Some biofibres from agricultural by-products, e.g. wheat straw, pineapple leaves, sugarcane bagasse, hop stems, Musaceae plants, quinoa etc are introduced. In addition, the fibres from different grass and legume species and from sea grass are presented in the article.

Keywords: plant fibres, sustainable fibres, untraditional fibres

Pregledni znanstveni članek *Scientific Review*

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Silicijev aerogel – supertoplotnoizolacijski material

Silica Aerogel – Thermal Superinsulation Material

V članku je predstavljen silicijev aerogel kot potencialni supertoplotnoizolacijski material za oblačila in tehnične tekstilije, namenjen rabi v ekstremnih temperaturnih okoljih. Opisani so danes znani postopki izdelave silicijevega gela iz vodnega stekla in alkoksidnih prekurzorjev ter ekstrakcije topila pri nadkritičnih in atmosferskih pogojih. Sodoben razvoj postopkov je usmerjen v cenejšo proizvodnjo aerogela, ki temelji na uporabi vodnega stekla in sušenju gela pri atmosferskih pogojih. V nadaljevanju članka so opisane nanoporozna struktura silicijevega aerogela in izstopajoče lastnosti, ki so majhna gostota ($3\text{--}350\text{ kgm}^{-3}$), visoka poroznost (80–99 %), velika specifična površina ($600\text{--}1000\text{ m}^2\text{g}^{-1}$), nizka toplotna prevodnost (pod $15\text{ mWm}^{-1}\text{K}^{-1}$), velika zvočna izolativnost in odlične absorpcijske sposobnosti. Ekstremne lastnosti silicijevega aerogela skupaj z negorljivostjo, kemično stabilnostjo in ekološko sprejemljivostjo omogočajo njegovo specifično rabo. Prav tako so opisane tudi nekatere slabosti silicijevega aerogela, med katere spadajo krhkost, prašenje in togost.

Ključne besede: silicijev aerogel, vodno steklo, silicijev alkoksid, toplotna superizolacija, nanoporoznost

This article presents silica aerogels as a potential super thermal insulation material for clothing and technical textiles to be used in extreme temperature environments. The well-known manufacturing process of silica gel from water glass and alkoxide precursors, and solvent extraction at supercritical and atmospheric conditions are described. The development of silica aerogel is directed towards a cheaper production, based on using water glass and drying the gel at atmospheric conditions. The following article describes the nanoporous structure of silica aerogels. The outstanding properties of silica aerogel are its low density ($3\text{--}350\text{ kgm}^{-3}$), high porosity (80–99%), large specific surface area ($600\text{--}1000\text{ m}^2\text{g}^{-1}$), low heat conductivity (below $15\text{ mWm}^{-1}\text{K}^{-1}$), great sound insulation and high absorption capacity. The extreme properties of silica aerogels, together with their inflammability, chemical stability and ecological acceptability enable their specific uses. The disadvantages of silica aerogels, e.g. fragility, dusting and rigidity are included as well.

Keywords: silica aerogel, water glass, silica alkoxyde, thermal superinsulation nanoporosity

Izvirni znanstveni članek *Original Scientific Paper*

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Razvoj tekstilne obrti v prvi polovici 20. stoletja

Development of Textile Craft in First half of 20th Century

Slovenija pred prvo svetovno vojno v okviru avstro-ogrške monarhije ni bila industrijska dežela. Redke tekstilne tovarne, med večjimi so bile tovarne v Litiji, Trziču in Ljubljani, so bile vse v tujih rokah. Po nastanku Kraljevine SHS se je položaj bistveno spremenil, kajti Slovenija je postala industrijsko najbolj razvita pokrajina prve Jugoslavije, prav tako se je močno povečal delež domačega kapitala. Z naraščajočo industrializacijo se je v gospodarstvu čedalje bolj uveljavljalo tudi slovensko obrtništvo. Cilj raziskave je bil prikazati položaj in obseg tekstilne dejavnosti v prvi polovici 20. stoletja in ugotoviti, kakšen je bil položaj tekstilnih obrtnikov po prvi svetovni vojni, med gospodarsko krizo in v letih pred drugo svetovno vojno, koliko jih je bilo, s kakšnimi problemi so se spopadali, kako so bili organizirani, ali so imeli zaposleno pomožno osebje in v kolikšni meri je razvoj tekstilne industrije vplival na propad obrti. Raziskava je pokazala, da so se v tem času v okoliših na novo nastale industrije v Sloveniji začele razvijati nove obrtne stroke, ki so predelovale npr. polizdelke tekstilnih tovarn. V zvezi s tekstilno stroko se je razvila obrt pleteninarjev (trikotaže), za potrebe tekstilne industrije so obrtniki strgarske in kartonažne stroke izdelovali razne tehnične potrebščine. Ta obrtniška proizvodnja deloma ni imela konkurence v industrijski proizvodnji, deloma pa je industrijsko proizvodnjo dopolnjevala. V raziskavi so poleg literature uporabljeni viri iz Arhiva Republike Slovenije (zapisniki občnih zborov in poročil o delovanju obrtnih zadrug in združenj, zapisniki sej Zbornice za trgovino, obrt in industrijo v Ljubljani, gradivo Okrožnega odbora obrtnih združenj v Ljubljani), Zgodovinskega arhiva v Ljubljani (adresarji mesta Ljubljane in okolice ter registri obrtnikov) in Zgodovinskega arhiva v Celju (fond mestne občine Celje 1918–1941, obrtne zadeve).

Ključne besede: tekstilna obrt, tekstilna industrija, zgodovina tekstilne industrije

Prior to the First World War, Slovenia – which was at the time a part of the Austro-Hungarian Empire – had a poorly developed industry. The few textile plants, the larger included works in Litija, Trzič and Ljubljana, were all in the hands of foreigners. Following the formation of the Kingdom of Serbs, Croats and Slovenes, the situation changed significantly. In addition to becoming industrially the most developed region of the so-called “First Yugoslavia”, the percentage of the local capital increased substantially. This industrialisation contributed greatly to the promotion and development of Slovenian crafts.

The objective of this research was to illustrate both the situation and extent of the textile industry in the first half of the 20th century, as well as to investigate the lives of textile craftspeople after the First World War, during the Great Depression and in the years before the Second World War, focusing on how many craftspeople there were, what problems they had to deal with, their organisation and whether they employed support staff, and to what extent the development of the textile industry affected the decline of craft making.

The research revealed that during this period, new trade branches started to develop within the districts of these newly established industries, e.g. the processing of semi-finished products of textile plants. Consequently, knitting crafts developed, whilst the craftspeople in the wood turning and cardboard box manufacturing started producing various technical requisites to meet the needs of the textile industry. The craft making either did not have any direct competition from these new industries or they supplemented it. In addition to the published materials, in this research, also the sources from the Archives of the Republic of Slovenia (minutes of annual meetings and reports on crafts cooperatives and associations, minutes of meetings by the Chamber of Commerce, Craft and Industry in Ljubljana, materials of the Regional Committee of Crafts Associations in Ljubljana), the Historical Archives of Ljubljana (directories of the city of Ljubljana and its surroundings and registers of craftsmen) and the Historical Archives of Celje (fund of Celje Municipality 1918–1941; crafts) were used.

Keywords: textile craft, textile industry, craft making, history of the textile industry