

**Izvirni znanstveni članek** *Original Scientific Paper*Marija Gorjanc<sup>1</sup>, Miran Mozetič<sup>2</sup>, Marija Gorenšek<sup>1</sup><sup>1</sup> Univerza v Ljubljani, Naravoslovnotehniška fakulteta, Oddelek za tekstilstvo, Snežniška 5, 1000 Ljubljana, Slovenija/*University of Ljubljana, Faculty of Natural Sciences and Engineering, Department of Textiles, Snežniška 5, SI-1000 Ljubljana, Slovenia*<sup>2</sup> Institut "Jožef Stefan", Jamova cesta 39, 1000 Ljubljana, Slovenija/*J. Stefan Institute, Jamova cesta 39, 1000 Ljubljana, Slovenia***Priprava bombažne tkanine z nizekotlačno plazmo za boljšo adhezijo nanosrebra***Low-Pressure Plasma for Pretreatment of Cotton Fabric for Better Adhesion of Nanosilver*

Z nizekotlačno plazmo, pri čemer sta bila kot plina uporabljena vodna para in  $CF_4$ , smo obdelali beljeno in mercerizirano bombažno tkanino. S plazmo obdelane in neobdeane tkanine so bile slepo barvane. V barvalno kopel smo dodali 20 mg/l nanosrebra velikosti 30 nm in 80 nm. Opravljen je bil test obstojnosti pri pranju pri 95 °C po standardu ISO 105-C03. Količina srebra, adsorbiranega na tkanine, je bila analizirana z metodo ICP-MS. Rezultati analize kažejo na povečano adsorpcijo nanosrebra na površino bombažne tkanine po obdelavi tkanine s plazmo in na desorpcijo nanosrebra po 10-kratnem pranju. Količina adsorbiranega srebra velikosti 30 nm je večja kot količina srebra velikosti 80 nm, vendar pa se tudi po pranju pokaže povečana desorpcija 30 nm srebra.

**Ključne besede:** bombaž, nizekotlačna plazma, vodna para,  $CF_4$ , nanodelci srebra.

*In this study, bleached and mercerized cotton fabric was treated with low-pressure plasma; water vapour and  $CF_4$  were used as gases. Some fabrics were treated with plasma and some were not; however, all of the fabrics were blank dyed. Twenty milligrams per liter of nanosilver (30 nm and 80 nm in size) was added to the dye-bath. A wash fastness test was conducted at 95°C in accordance with the ISO 105-C03 standard. The amount of silver adsorbed onto the fabric was analyzed by the ICP-MS method. The analysis results revealed that the adsorption of nanosilver increased on the surface of the cotton fabric after the plasma treatment while the nanosilver desorbed after ten wash cycles. The amount of adsorbed silver that was 30 nm in size was larger in comparison to the 80 nm-sized silver; nevertheless, after the wash, desorption of the 30 nm-sized silver increased.*

**Keywords:** cotton, low-pressure plasma, water vapour,  $CF_4$ , nanosilver particles

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Kapok (*Ceiba pentandra*) je naravno celulozno vlakno z izrazitim lumnom in okroglim do ovalnim prečnim prerezom. Je eno najučinkovitejših vlaken za oljne absorberje, kjer prekaša sintetična vlakna. Mehanizem sorpcije olj v kapokova vlakna ni popolnoma proučen. Odlične sorpcijske sposobnosti pripisujejo zadrževanju tekočin v lumnu vlaken. V članku so predstavljeni izsledki raziskave votlosti kapoka in sposobnosti zadrževanja tekočin po triurnem namakanju in centrifugiranju vlaken ter mehanizem površinske adsorpcije vode in olja. Geometrijski indeksi surovega kapoka so bili izmerjeni in izračunani na podlagi izmerjenih parametrov prečnega prereza surovih vlaken: debelina celične stene 1,01  $\mu$ m, razmerje med premerom lumna in premerom vlakna ( $d/D$ ) 0,85, votlost 73,08-odstotna, gostota vlaken je 0,3968 g/cm<sup>3</sup>, zunanja specifična površina 0,2324  $\mu$ m/ $\mu$ m<sup>2</sup> oziroma 0,6678 m<sup>2</sup>/g. Ob stiku suhih vlaken kapoka s tekočino je bilo opaženo počasno širjenje vode po površju vlaken, olje pa se je razširilo zelo hitro. Voda že takoj ob stiku s kapokovimi vlakni začne prodirati v lumen vlaken. Olje počasneje prodira v lumen vlaken kot voda. Zelo malo olja je prodrlo v lumen kapoka v začetnih minutah, po daljšem času namakanja pa je olje dobro zapolnilo lumen kapoka. Povprečni volumen lumna kapoka je 2,1 cm<sup>3</sup> na gram absolutno suhih vlaken, kar pomeni kapaciteto vlaken za zadrževanje tekočine v lumnu. Izmerjene količine zadržane vode po triurnem namakanju in centrifugiranju so bile 1,03 g za vodo, za jedilno olje 1,32 g in za parafinsko olje 1,07 g na gram absolutno suhih vlaken. Količina zadržanega olja, ki ostane v kapoku po centrifugiranju, je manjša od kapacitete lumna in pomeni le nekaj odstotkov celotne količine vsebovanega olja v namakanih vlaknih pred centrifugiranjem. Centrifugiranje omogoča visok odstotek regeneriranja olj iz kapokovih filtrov in njihovo ponovno uporabo.

**Ključne besede:** kapok, votlost vlaken, geometrijski indeksi votlih vlaken, količina zadrževane tekočine.

*Kapok (*Ceiba pentandra*) is a natural cellulose fibre with an extraordinary lumen and round-to-oval cross-section. It is one of the most efficient fibres for oil absorbers where it even outperforms synthetic fibres. The mechanism of oil sorption into kapok fibres has not been entirely researched yet. Excellent sorption capacities are attributed to the retention of oils in the kapok fibre lumen. The paper is*

going to present the results of measurements of the kapok fibres hollowness, and the capacity of kapok fibers to retain liquids after having been soaked for 3 hours and centrifuged, as well as the mechanism of water and oil surface adsorption. Geometrical indices of raw kapok were measured or calculated based on the measured parameters of the raw fibres cross-sections: thickness of the cell wall 1.01  $\mu\text{m}$ , the lumen diameter to fibre diameter ratio ( $d/D$ ) 0.85, percentage of the hollowness 73.08%, volume of the raw kapok lumen 2.1  $\text{cm}^3/\text{g}$ , density of fibres 0.3968  $\text{g}/\text{cm}^3$ , specific surface area per volume unit 0.2324  $\mu\text{m}/\mu\text{m}^2$  and per weight unit 0.6678  $\text{m}^2/\text{g}$  resp. It has been noticed that at contact of dry kapok fibres with liquid, water is spreading slowly over the surface of fibres whereas oil spreads very quickly. Water starts to penetrate into the fibre lumen as soon as it comes into contact with kapok fibres. Oil penetrates into the fibre lumen at a slower rate than water. In the first few minutes only a very low amount of oil penetrated into the kapok fibre lumen, however, after a longer period of time, oil filled the kapok fibre lumen very well. The mean volume of a kapok fibre lumen is 2.1  $\text{cm}^3$  per 1 gram of absolutely dry fibres, which represents the capacity of fibres to retain liquid in their lumen. The measured mean amount of the retained liquid in kapok fibres after the fibres have been soaked for 3 hours and centrifuged was 1.03 g in the case of water, 1.32 g in the case of cooking oil and 1.07 g in the case of paraffin oil per 1 g of absolutely dry fibres. The quantity of oil retentioned in kapok after centrifugation was lower than capacity of fibres lumen which presents only few percentages of the whole quantity of retentioned oil in kapok fibres before centrifugation. Centrifugation process enables a highly percentage of oil regeneration and reuse of kapok filters.

**Keywords:** kapok, fibre hollowness, geometrical indices of hollow fibres, amount of retained liquid

### Pregledni znanstveni članek *Scientific Review*

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### Čiščenje tekstilnih odpadnih voda s postopkom $\text{O}_3$ in $\text{H}_2\text{O}_2/\text{O}_3$

*Textile Wastewater Cleaning with  $\text{O}_3$  and  $\text{H}_2\text{O}_2/\text{O}_3$  Process*

V članku sta predstavljena postopka ozoniranje ( $\text{O}_3$ ) in  $\text{H}_2\text{O}_2/\text{O}_3$ , kot dva izmed učinkovitejših postopkov za čiščenje tekstilnih voda. Podane so različne sestave in lastnosti barvalnih kopeleli in odplak, predstavljeni so konvencionalni postopki čiščenja ter

njihove slabosti. Poglobljeno sta prikazana in razložena postopka ozoniranja in  $\text{H}_2\text{O}_2/\text{O}_3$  ter pregled literature, ki se nanaša na ozoniranje in  $\text{H}_2\text{O}_2/\text{O}_3$  postopek čiščenja tekstilnih barvalnih kopeleli, ki vsebujejo barvila z različnimi kromofornimi skupinami.

V nadaljevanju članka je podana učinkovitost postopka ozoniranja in  $\text{H}_2\text{O}_2/\text{O}_3$  pri različnih eksperimentalnih pogojih za razbarvanje in zniževanje ekoloških parametrov. Iz pregleda literature je razvidno, da se postopka ozoniranje in  $\text{H}_2\text{O}_2/\text{O}_3$  veliko uporabljata za odstranjevanje reaktivnih, kislih in direktnih barvil. Manj podatkov je o bazičnih, disperznih in kovinsko-kompleksnih barvilih.

**Glavne besede:** tekstilne obarvane vode, barvila, učinkovitost čiščenja, ozoniranje,  $\text{H}_2\text{O}_2/\text{O}_3$

The paper describes the ozonation ( $\text{O}_3$ ) and  $\text{H}_2\text{O}_2/\text{O}_3$  process as two efficient methods for cleaning textile effluents. The composition and characteristics of differently coloured dyebath effluents and wastewaters, as well as conventional processes and their disadvantages are stated. The presentation of the ozonation and  $\text{H}_2\text{O}_2/\text{O}_3$  process reactions and a review of applications for textile dyebath effluents loaded with different dye types of various chromophore groups are given precisely.

Furthermore, the paper states the ozonation and  $\text{H}_2\text{O}_2/\text{O}_3$  process efficiency for the removal of various dye types at different experimental conditions. The literature review shows that the ozonation and  $\text{H}_2\text{O}_2/\text{O}_3$  process are mainly used for reactive, acid and direct dyes treatment. Less information is available on basic, disperse and metal-complex dyes.

**Keywords:** textile coloured wastewater, dyes, cleaning efficiency, ozonation, ozone,  $\text{H}_2\text{O}_2/\text{O}_3$

### Izvirni znanstveni članek *Original Scientific Paper*

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### Raziskava kompaktnega predenja za preje iz regenerirane celuloze in sintetične preje *Compact Spinning Research for Regenerated Cellulose and Synthetic Yarns*

V tej raziskavi smo primerjalno proučevali fizikalne lastnosti kompaktnih in klasičnih predvnihih prej. Za ta namen smo izdelali kompaktne in klasične prstanske preje v treh debelinah niti in s tremi stopnjami vitja. Kot surovino smo uporabili stenj iz 100 % modala, 100 % poliestra, 100 % tencela in 100 % viskoze.

Rezultati raziskave se pokazali, da so kompaktne preje v primerjavi s klasičnimi prstanskimi prejami manj kosmate, trdnješe in imajo višje vrednosti razteznega razmerja.

Razlike v kosmatosti in nateznih lastnostih med kompaktnimi in klasičnimi prstanskimi prejami so odvisne od surovine, uporabljene v postopku predenja. Z mehanskim kompaktnim prede-

njem se izboljšajo kakovostne lastnosti prej, ki se bolje predejo z viskozniimi štapelnimi vlakni kot z drugimi surovinami, ki smo jih uporabili v raziskavi.

**Ključne besede:** mehansko kompaktno predenje, klasično prstansko predenje, modal, tencel, poliester, viskoza, fizikalne lastnosti preje

*This study is a comparative study of physical properties of compact and conventional spun yarns. For this aim, compact and conventional ring yarns were produced at three yarn counts having three-twist levels. 100% modal, 100% polyester, 100% tencel and 100% viscose rovings were used as raw materials in the study.*

*The results showed that compact yarns have less hairiness, higher strength and higher elongation ratio values than conventional ring yarns.*

*The differences in hairiness and tensile properties between compact and conventional ring yarns depend on the raw material used in spinning. Mechanical compact spinning improves the quality properties of yarns, which spun with viscose staple fibres better than other raw materials used in the study.*

**Keywords:** mechanical compact spinning, conventional ring spinning, modal, tencel, polyester, viscose, yarn physical properties

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## Nova vlakna za 21. stoletje

### Novel Fibres for the 21<sup>st</sup> Century

Članek obravnava najvidnejše razvojne dosežke na področju vlaknen v zadnjih nekaj letih: nanovlakna, kemično pajkovo svilo, gensko spremenjen bombaž, vlakna iz polimlečne kisline, inteligentna vlakna, vlakna z negativnim Poissonovim številom, sojina vlakna, vlakna iz ptičjega perja in nova poliestrska vlakna z latentno elastičnostjo.

**Ključne besede:** nanovlakna, kemična pajkova svila, BioSteel, Bt bombaž, polimlečna kislina, PLA, sojina vlakna, vlakna iz ptičjega perja, optična vlakna, vlakna z negativnim Poissonovim številom, Corterra, Sorona, Securus, polibutilen tereftalat, PBT, politrimetilen tereftalat, PTT, triexta, elesterell-p, elastomultiester

*The paper deals with the most prominent advances in the field of fibres in the last few years: nanofibres, man-made spider silk, genetically altered cotton (Bt-cotton), polylactide (PLA) fibres, intelligent fibres, auxetic fibres (negative Poisson's number fibres), soybean fibres, feather fibres, and new polyester fibres with latent elasticity.*

**Keywords:** nanofibres, man-made spider silk, BioSteel, Bt-cotton, polylactide (PLA) fibres, soybean fibres, feather fibres, optical fibres, auxetic fibres, Corterra, Sorona, Securus, polybutylene terephthalate, PBT, polytrimethylene terephthalate, PTT, triexta, elasterell-p, elastomultiester