

### Izvirni znanstveni članek *Original Scientific Paper*

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### Uporaba ATR IR spektroskopije pri preučevanju strukturnih sprememb celuloznih vlaken

*The use of ATR IR spectroscopy in the study of structural changes of the cellulose fibres*

Namen raziskave je bil preučiti uporabnost ATR IR spektroskopije pri študiju strukturnih sprememb celuloznih vlaken. Izbrali smo dva primera preoblikovanja, in sicer sol-gel postopek kemijske apreture vlaken z novim sredstvom na podlagi silana ter proces biorazgradnje vlaken pod vplivom mikroorganizmov. Analiza spektrov je pokazala, da se lahko z ATR IR spektroskopijo podrobno določijo kemijske lastnosti nanokompozitne aperture prevleke kljub njeni izredno majhni debelini (< 100nm), prav tako pa se razkrijejo strukturne spremembe nanokompozitne prevleke oplemenitenih vlaken po večkratnem pranju. ATR IR spektroskopija je prav tako primerna za spremljanje biorazgradnje celuloznih vlaken, pri čemer smo določili spremembe v kristalnosti oziroma amorfности vlaken v odvisnosti od časa biorazgradnje, hidrolitične in oksidacijske poškodbe celuloze ter stopnjo rasti mikroorganizmov na vlaknih.

**Ključne besede:** celuloza, ATR IR spektroskopija, kemijska apertura, sol-gel tehnologija, biorazgradnja.

*In the present study the application of an ATR IR spectroscopic technique on the structural changes of the cellulose fibres was studied. Two examples of the cellulose modification were studied, i.e. the finishing of cotton fibres with a novel silane precursor and the biodegradation of cotton fibres with microorganisms. It was demonstrated that the analysis of the ATR IR spectra is an appropriate method for determining the chemical properties of the thin (< 100 nm) nanocomposite film, as well as for determining its structural changes after repeated washing of finished fibres. We also showed that the ATR IR spectroscopy is appropriate for investigating the biodegradation study of cellulose fibres, as interred from the changes of crystallinity and amorphous regions of the fibres, hydrolytic and oxidative degradation of the cellulose, as well as microbial growth on the fibres.*

**Key words:** cellulose, ATR IR spectroscopy, chemical finishing, sol-gel technology, biodegradation.

### Pregledni znanstveni članek *Review*

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### Pektinaze kot sredstvo za bioizkuhavanje *Pectinases as agents for bioscouring*

Encimi pektinaze v tekstilni industriji pridobivajo čedalje večji pomen. Uporablja se jih kot sredstvo za izkuhavanje bombaža, obdelava se imenuje bioizkuhavanje. Tako je že tudi na industrijski ravni razvitih več postopkov izkuhavanja, ki pa v praksi še niso povsem zaživi. Obdelava poteka pri razmeroma nizki temperaturi v šibko kislem ali alkalnem mediju, kar je odvisno od vrste pektinaz. Pektinaze razcepijo pektin v vrhnji plasti bombažnih vlaken na manjše vodotopne molekule. Zaradi specifičnega delovanja pektinaz ne pride do poškodb celulozne verige. Z razgradnjo pektina se lažje odstranijo tudi ostale necelulozne snovi iz bombažnega vlakna. Vpojnost je zadostna za sledeče postopke obdelav. Odpadne vode niso obremenjene s škodljivimi kemikalijami.

**Ključne besede:** encimi, pektinaze, izkuhavanje, celulozna vlakna.

*The enzymes pectinases are gaining in importance in the textile industry. They are being used as an agent in scouring of cotton, such treatment of textile is called bioscouring. Several processes of scouring have been developed on industry level, however their use has not yet come to practical use. The treatment is carried out at considerably low temperatures in a weak acid or in alkaline medium, depending on the sort of pectinases. The pectinases decompose the pectin in the upper layer of cotton fibres to smaller water soluble molecules. Due to a specific activity of the pectinases, damages do not occur in the cellulose chains. Moreover, other non-cellulosic substances are easily removed from the cotton fibres by degradation of pectin. The absorption is sufficient for the following procedures of treatment. Waste waters are not charged with harmful chemicals.*

**Key words:** enzymes, pectinases, scouring, cellulose fibres.

## Izvorni znanstveni članek *Original Scientific Paper*

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### Vpliv strukture neionskega tenzida na interakcije tenzid-tenzid

*Influence of the nonionic surfactant structure on surfactant-surfactant interactions*

V prispevku je predstavljen vpliv strukture neionskega tenzida na interakcije med kationskim tenzidom in micelom neionskega tenzida v vodni raztopini pri temperaturi 25 °C. V raziskavo so vključeni kationski tenzid dodeciltrimetilamonijev bromid (DTA) in sedem neionskih tenzidov različnih struktur, in sicer Brij 30 (BR30), Brij 35 (BR35), Brij 56 (BR56), Brij 58 (BR58), Brij 700 (BR700), Triton X-100 (TX100) in Tween 20 (TW20). Interakcije so preučevane s potenciometrično metodo z uporabo ionoselektivne membranske elektrode, občutljive na proste katione tenzida DTA. Določeni sta ravnotežna konstanta,  $\kappa$ , in sprememba standardne proste energije,  $\Delta G_1^\circ$ , nastanka kompleksa tenzid-tenzid. Izsledki raziskave kažejo, da je jakost vezanja kationa tenzida DTA v micel neionskega tenzida odvisna od velikosti in oblike hidrofilne kot tudi hidrofobne skupine neionskega tenzida. Neionski tenzid s krajšo hidrofilno polioksietilensko skupino tvori šibkejšje interakcije s kationom tenzida DTA kot neionski tenzid z daljšo hidrofilno skupino pri enaki dolžini hidrofobne verige. Prav tako tvori neionski tenzid z daljšo hidrofobno verigo močnejše interakcije s kationom tenzida DTA kot neionski tenzid s krajšo hidrofobno verigo pri enaki velikosti hidrofilne skupine. Razvejanje hidrofobne ali hidrofilne skupine neionskega tenzida zmanjša jakost medmolekulskih interakcij. Iz tega sledi, da so za vključitev kationa DTA v micel neionskega tenzida pomembne tako elektrostatske interakcije, ki potečejo med kvarternim dušikovim atomom tenzida DTA in polioksietilensko skupino neionskega tenzida, kot tudi hidrofobne interakcije med ogljikovodikovima verigama obeh tenzidov.

**Ključne besede:** kationski tenzid, neionski tenzid, medmolekulske interakcije, jakost interakcij, vpliv strukture, termodinamika, potenciometrija.

*This paper presents the influence of the structure of nonionic surfactant on interactions between a cationic surfactant and the micelle of a nonionic surfactant in aqueous solution at 25 °C. Cationic surfactant dodecyltrimethylammonium bromide (DTA) and seven nonionic surfactants of different structure--Brij 30 (BR30), Brij 35 (BR35), Brij 56 (BR56), Brij 58 (BR58), Brij 700 (BR700), Triton X-100 (TX100) and Tween 20 (TW20)--were used in this research. Interactions have been studied by means of potentiometry,*

*based on the use of ion-selective membrane electrode sensitive to free DTA surfactant cations. The equilibrium constant,  $\kappa$ , and the standard free energy change,  $\Delta G_1^\circ$ , for surfactant-surfactant complex formation, were determined. The results show that the strength of binding of DTA surfactant cations into the micelle of nonionic surfactant is dependent upon the length and shape of both hydrophilic and hydrophobic groups of the nonionic surfactant. A nonionic surfactant with shorter hydrophilic polyoxyethylene group forms weaker interactions with a DTA surfactant cation than a nonionic surfactant with a longer hydrophilic group, with the length of their hydrophobic groups being equivalent. A nonionic surfactant with a longer hydrophobic chain also forms stronger interactions with a DTA surfactant cation than a nonionic surfactant with a shorter hydrophilic chain, assuming the magnitude of their hydrophilic groups is the same. Branching of both the hydrophilic and hydrophobic group of a nonionic surfactant reduces the strength of intermolecular interactions. It can thus be concluded that the electrostatic interactions occurring between a quaternary ammonium atom of a DTA surfactant and polyoxyethylene group of a nonionic surfactant as well as the hydrophobic interactions occurring among hydrocarbonium chains of both surfactants are important for incorporation of DTA cations into the micelle of a nonionic surfactant.*

**Key words:** cationic surfactant, nonionic surfactant, intermolecular interactions, strength of interactions, the influence of the structure, thermodynamics, potentiometry.