

immunization by sodium aluminate because, despite the various experiments carried out, it is still not absolutely clear.



## Acknowledgements

The research was carried out as part of the project "Processing of leather without calcium compounds" BEKALCE ODA MIP-021/2014 supported by the Research Council of Lithuania.

## References

- Cranston RW, Davis M, Scroggie J.G. Development of the "sirolime" unhairing process. *J Am Leather Chem As* 1986; 81: 347-355.
- Thanikaivelan P, Rao JR, Nair BU, Ramasami T. Zero Discharge Tanning: A Shift from Chemical to Biocatalytic Leather Processing. *Environ Sci Technol* 2002; 6: 4187-4194.
- Karthikeyan R, Balaji S, Sehgal PK. Industrial applications of keratins – A review. *J Sci Ind Res India* 2007; 66: 710-715.
- Dettmer A, Cavalli E, Ayub MAZ, Gutterres M. Environmentally friendly hide unhairing: enzymatic hide processing for the replacement of sodium sulfide and delimiting. *J Clean Prod* 2013; 47: 11-18.
- Wang R, Min C, Haiming C, Zhiqiang L. Enzyme unhairing – an eco-friendly biotechnological process. *J Soc Leath Tech Ch* 2009; 93: 51-55.
- Thanikaivelan P, Rao JR, Nair BU, Ramasami T. Progress and recent trends in biotechnological methods for leather processing. *Trends Biotechnol* 2004; 22: 181-188.
- Valeika V, Beleska K, Sirvaityte J. Alkali-free method of hide preparation to tanning. *Braz J. Chem Eng* 2012; 29: 315-323.
- Frendrup W. Hair-save unhairing methods in leather processing (report), US/RAS/92/120. *Regional Programme for Pollution Control in the Tanning Industry in South-East Asia, United Nations Industrial Development Organization, 12 September 2000, 7-8, 2000.*
- Bienkewicz K. *Physical chemistry of leather making*. Robert E. Krieger publishing Co. Inc., Malabar, Florida, 1983.
- Heidemann E. *Fundamentals of leather manufacturing*, Eduard Roetger KG druckerei und Verlag, Darmstadt, 1993.
- Cantera CS. Hair-saving unhairing process Part 2. Immunization phenomenon. *J Soc Leath Tech Ch* 2001; 85: 1-5.
- Castiello D, Puccini M, Shelly D, Vitolo S. Studies of mono and divalent cations effects on hair immunization *J Am Leather Chem As* 2007; 102: 341-346.
- Thanikaivelan P, Rao, JR, Nair BU and Ramasami, T. Approach towards zero discharge tanning: Exploration of NaOH based opening up method. *J Am Leather Chem As* 2001; 96: 222-233.
- Sirvaityte J, Beleska K, Valeika V. Lime free unhairing: Sodium aluminate as an alternative towards a cleaner process *J Am Leather Chem As* 2016; 111: 406-412.
- Saravanabhavan S, Thanikaivelan P, Rao JR, Nair BU and Ramasamit T. Sodium metasilicate based fiber opening for greener leather processing. *Environ Sci Technol* 2008; 42:1731-1739.
- Valeika V, Sirvaityte J, Beleska K, Alaburdaite R, Valeikiene V. Immunization action of sodium silicate on hair. *J Soc Leath Tech Ch* 2015; 99: 223-230.
- Sirvaityte J, Beleska K, Valeikiene V, Plavan V, Valeika V. Immunization action of sodium silicate on hair: Part 2, Hair-save process based on lime substitution by sodium silicate. *J Soc Leath Tech Ch* 2015; 99: 231-237.
- Strazdas K, Raiselis J, Vaickelionis G. *Tirpusis ir skystasis stiklas*, Technologija, Kaunas, Lithuania, 2004 (in Lithuanian).
- Golovteeva E, Kutsidi A, Sankin L. *Laboratornyj praktikum po khimiyi i tekhnologiyi kozhy i mekha*. Legkaiya i Pischevaiya Promyslenost, Moscow, 1982 (in Russian).
- Buika G, Getautis V, Martynaitis V, Rutkauskas K. *Spectroscopy of organic compounds*. Vitae Litera, Kaunas, Lithuania, 2007 (in Lithuanian).
- Bendit, EG. Infrared absorption spectrum of keratin. I. Spectra of alpha-, beta-, and supercontracted keratin. *Biopolymers* 1966; 4: 539.
- Kong J and Yu S. Fourier transform infrared spectroscopic analysis of protein secondary structures. *Acta Biochim Biophys Sin* 2007; 39: 549-559.
- Espinoza EO, Baker BW, Moores TD, Voin D. Forensic identification of elephant and giraffe hair artifacts using HATR FTIR spectroscopy and discriminant analysis, *Endanger Species Res* 2008; 9: 239-246.
- Lipp-Symonowicz B, Sztajnowski S, Kułak A. (2012). IR Spectroscopy as a Possible Method of Analysing Fibre Structures and Their Changes Under Various Impacts, Infrared Radiation, Dr. Vasył Morozhenko (Ed.), InTech, DOI: 10.5772/37155. Available from: <http://www.intechopen.com/books/infrared-radiation/ir-spectroscopy-as-a-possible-method-of-analysing-fibre-structures-and-their-changes-under-various-i>
- Wojciechowska E, Wlochowicz A, Weselucha-Birczyrska A. Application of Fourier-transform infrared and Raman spectroscopy to study degradation of the wool fiber keratin. *J Mol Struct* 1999; 511-512: 307-318.

Received 23.05.2016 Reviewed 02.06.2017



Institute of Biopolymers  
and Chemical Fibres

## Multifilament Chitosan Yarn

The Institute of Biopolymers and Chemical Fibres is in possession of the know-how and equipment to start the production of continuous chitosan fibres on an extended lab scale. The Institute is highly experienced in the wet – spinning of polysaccharides, especially chitosan. The Fibres from Natural Polymers department, run by Dr Dariusz Wawro, has elaborated a proprietary environmentally-friendly method of producing continuous chitosan fibres with bobbins wound on in a form suitable for textile processing and medical application.



Multifilament chitosan yarn

We are ready, in cooperation with our customers, to conduct investigations aimed at the preparation of staple and continuous chitosan fibres tailored to specific needs in preparing non-woven and knit fabrics.

We presently offer a number of chitosan yarns with a variety of mechanical properties, and with single filaments in the range of 3.0 to 6.0 dtex.

The fibres offer new potential uses in medical products like dressing, implants and cell growth media.

For more information please contact:  
Dariusz Wawro Ph.D., D. Sc., Eng  
Instytut Biopolimerów i Włókien Chemicznych  
ul. Skłodowskiej-Curie 19/27;  
90-570 Łódź, Poland;  
Phone: (48-42) 638-03-68, Fax: (48-42) 637-65-01  
E-mail: [dariusz.wawro@ibwch.lodz.pl](mailto:dariusz.wawro@ibwch.lodz.pl)