DYEING OF ENZYMATIC TREATED HEMP FIBRE BY MICROWAVE METHOD

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Abstract

Microwave method is quite new method for textile wet processes and it has some advantages such as low energy requirement and fast process duration. Treatment of cellulose fibres before dyeing process effects the colour values of the natural fibres. In this study, hemp fibres were treated with laccase enzyme in different concentrations (1%, 2% and 3%). Conventional and microwave methods were used for the enzymatic treatment of hemp fibres. After enzymatic treatment, tensile strength and elongation properties of the treated hemp fibres were investigated.

Key words: Hemp fiber, microwave energy method, laccase enzyme

1. Introduction

Enzymes are biocatalyst produced from bacterial derivatives of living organisms. Catalysts are the substances which remain unchanged after chemical and biochemical reactions[1].
Bio-catalytic enzyme technology is an environment friendly method therefore it is used in medicine, pharmacy, agriculture, livestock, environment, feed, paper, detergent and textile industries. In textile industry, different enzymes are used for different purposes such as *amilase*; to remove size, cellulase; enzymatic washing of jeans and denim clothes, *protease*; for silk and wool fibers, *catalase*; for removing of hydrogen peroxide after bleaching, *laccase*; enzymatic removing of indigo dyes for denim fabrics, *peroksidaz*; oxidation of unbonded dyes for reactive dyestuffs, *lipase*; to remove oil for spinning, *pectinase*; for biocleaning of raw cotton or flax. Polyesteraz and poliamidaz bacterias are found for polyester and polyamide fibers. These bacterias have ability to decompose the PES and PA. It is considered that all textile industry will be controlled by the bio-technology in the futur[2].
In order to obtain strong bond between matrix and reinforcement material of composite structures, surface of the reinforcement material is roughed, and mechanical bond is increased. Many researches have been studied on application of chemical methods to increase the adhesion between matris and reinforcement material. 18% sodium hydroxide is the most proper concentration of the surface modification of the sisal fibre[3], properties of the alkali treated sisal fibre/polylactic acid composites were investigated[4], surface treatment of jute fibre with oligomeric siloxane before production of jute fibre/LDPE composites[5], application of mercerization, cyanoethilation and coupling agent to imrove the adhesion of jute fibre/HDPE composites[6], many researches have been studied for the surface modification of the bamboo fibre by using maleic anhydride, permanganate, benzoyl chloride and benzyl chloride[7].

Enzymes can find application field in technology of fibre reinforced composites and fibre modification, enzymes hydrolyse the fibre under control. Enzymatic retting process which used in textile industry is referenced to surface modification of the lignocellulosic fibres. Pectinase enzyme is used for the biological retting process of the flax[8], and cellulaz, xylanaz and laccase enzmes were used for the biological retting process of the hemp and this process were compared with mechanical and chemical processes[9].
Effects of bacterial pectinolytic enzymes on the retting process of the flax were investigated[10], effects of retting process on the thermal and mechanical properties of the flax/polypropylene composites were investigated[11], properties of the enzymatic retted flax fibres/recycled polyethylene were studied[12]. Abaca fibres which modified by fungamix and natural enzymes were used in poypropylene composites[13]. bamboo fibres were modified with Protemase K ve Lipase PS commercial enzymes[14]. Pectinolytic enzyme and Ethylene Diamine Tetraacetic Acid (EDTA) were used in composite applications[15]. Surface properties of the glucose oxidase-laccase treated and untreated flax fibre were investigated on the gas chromatography[16], effect of the conventional, ultrasonic and microwave methods on the enzymatic treatment of the luffa fibres were investigated[17].
Hemp (Cannabis satival) is a widely grown lignocellulosic plant. Large amounts of hemp noil as a by-product is produced, which amounts to 1.2–1.4 ton per each ton of hemp yarn when hemp fiber is processed to textile[18]. The utilization ratio of hemp is low and huge amounts of noil need to be disposed of. Hence more application fields should be found for the use of short hemp fiber. Hemp fiber has excellent mechanical properties also it is biodegradable, it was used in the automotive industry mostly as interior components[19].

2. Experimental

2.1. Materials

Hemp fibres overall lengths were between 400mm and 600mm. Hemp fiber were washed with water to remove the adhering dirt for 30 min at 20^{O}C in distilled water. They were dried in an oven for 6 hours at 70^{O} C. After drying, they were conditioned for 48 hours prior to testing under ±20°C and 65±2 RH% condition**.**

2.2.Chemical Treatments of Luffa Fibers Treatments

Hemp fibers have been exposed into two methods in which are given conventional method and microwave energy method in Table 1.
Microwave energy method with a Galanz/WP800T was carried out at a frequency of 2.45 GHz. The microwave oven had a maximal power of 800 W with six discrete settings. The mixtures were placed in a sealed glass vessel and treated by the microwave according to the experimental design.

Table 1. Conventional Method Applied to the Hemp Fibers

Methods	**Solution (chemicals)**	**Concentration**	**Temperature (^{0}C)**	**Time (min)**	**Rinsed process** (25^{o} C,10 min, pH 7)	**Dry process**
Conventional method	Laccasse enzyme	1-2-3 %	40	20-40	distilled water	At room temperature
Microwave method	Laccasse enzyme	1-2-3%	40	1-3	distilled water	At room temperature

2.3.Testing and Characterization of Hemp Fibres After Chemical Treatments

After application of the conventional and microwave methods on hemp fibres (single fibres length 10 mm) mechanical characteristic values of the hemp fibres were performed based on ASTM D 3822 with Instron 4411 (50 N load, speed of 10 mm/min) resistance device.

3. RESULTS AND DISCUSSION

3.1.Mechanical Properties

Tensile strength and elongation properties of the surface treated hemp fibres by using conventional method and laccase enzyme in different concentrations are given in Figure 1 and Figure 2. Tensile strength and elongation properties of the surface treated hemp fibres by using microwave method and laccase enzyme in different concentrations are given in Figure 3 and Figure 4.

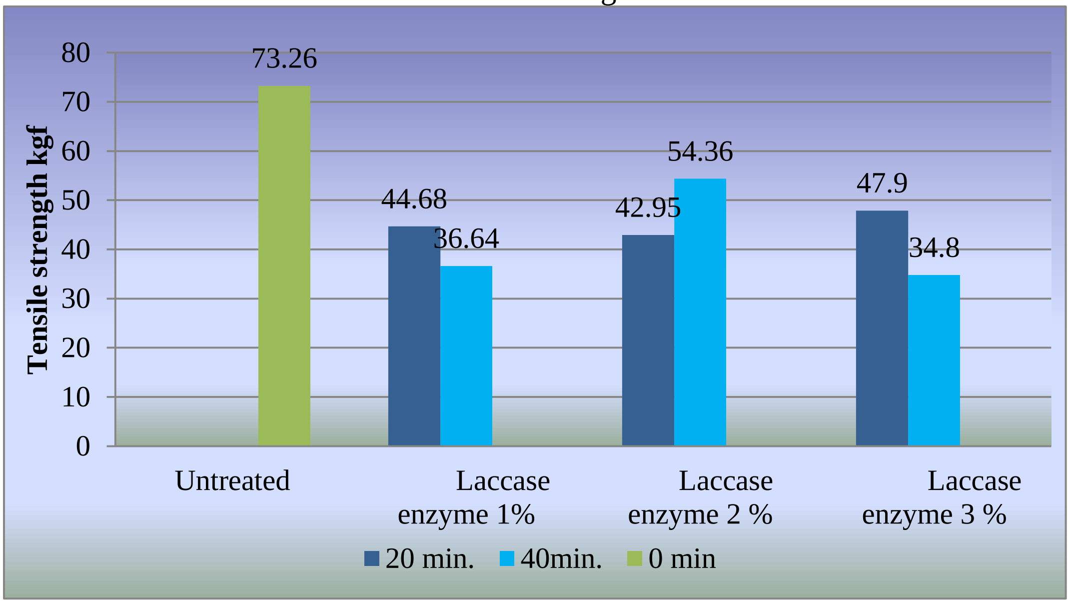

Figure 1. *Tensile strength properties of the surface treated hemp fibres by using conventional method*

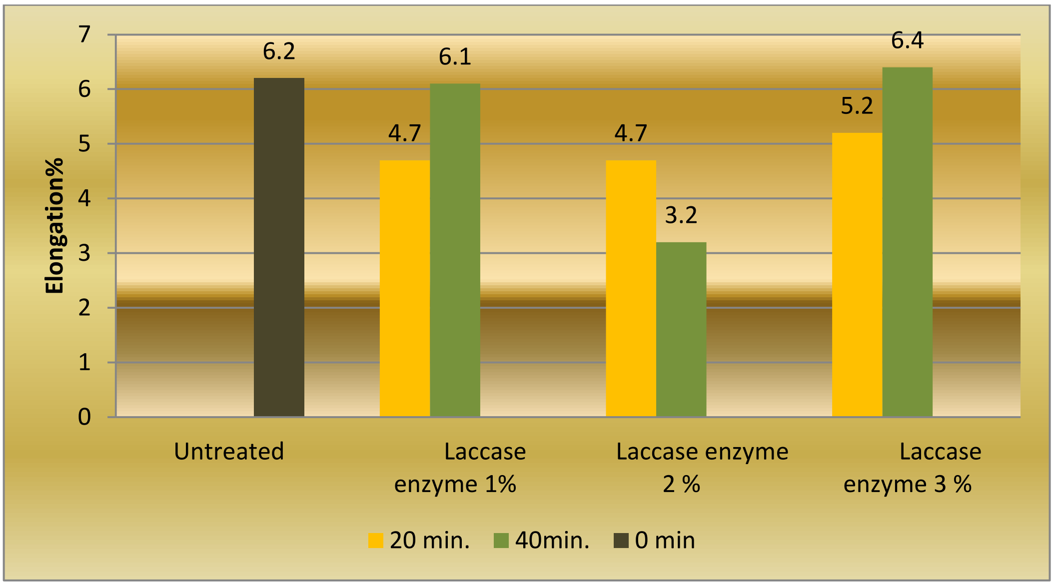

Figure 2. *Elongation properties of the surface treated hemp fibres by using conventional method*

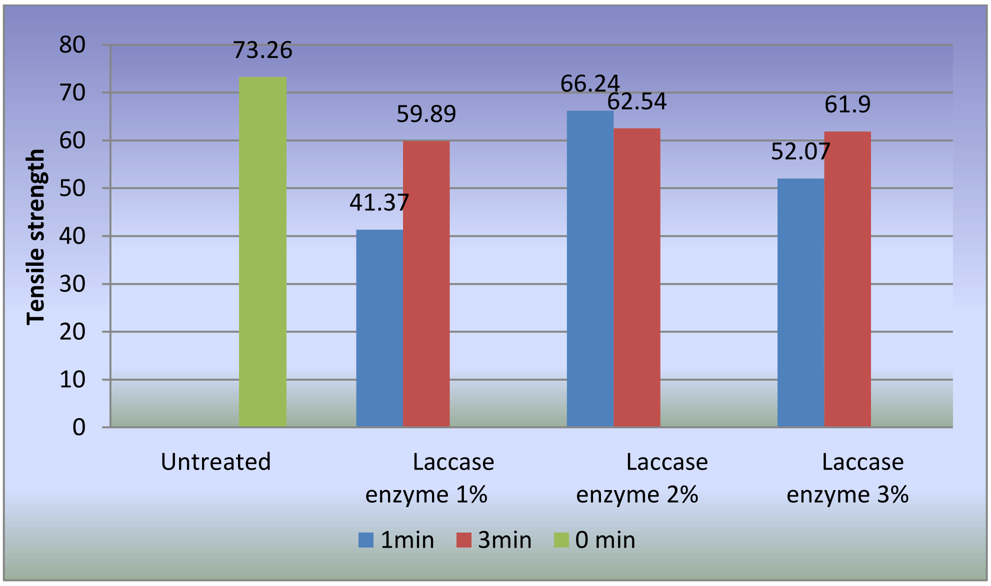

Figure 3. *Tensile strength properties of the surface treated hemp fibres by using microwave energy method*

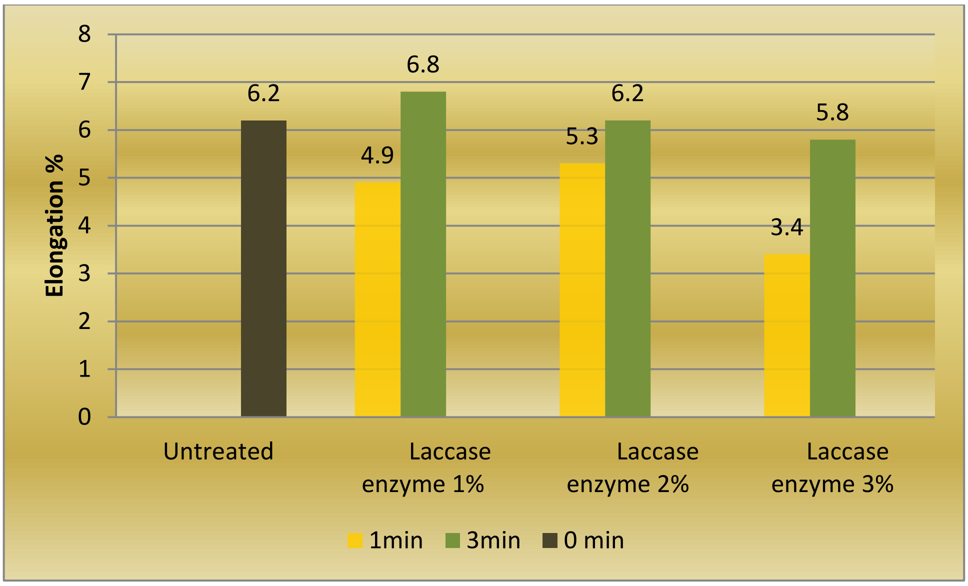

Figure 4*. Elongation properties of the surface treated hemp fibres by using microwave energy method*

According to the figures tensile strength and elongation values of the hemp fibres were decreased after conventional and microwave energy surface treatment processes. The reason of that decrease is removing of lignin and hemicelluloses from the hemp fibre. When the treatment methods were compared, less decrease was obtained from the microwave energy method, because this method is shorter than conventional method. 2% laccase enzyme concentration is optimum for tensile strength properties. 1% laccase enzyme concentration is optimum for elongation properties. Tensile strength and elongation values were decreased by increasing the laccase enzyme concentration.

Microwave method decreased the time and energy consumption of the treatment processes. And after microwave treatment processes less decrease was obtained from tensile strength and elongation values than conventional method, therefore this method can be used as an alternative method.

References

[1] Stöhr, R., Enzymes –Biocatalysts in Textile Finishing, Melliand International (4) 95,p.261-264.

[2] Galante M.Y., Formantici C., (2003), Enzyme Applications in Detergency and in Manufacturing Industries, Current Organic Chemistry, 7,1399-1422.

[3] Padmavathi T., Venkata Naidu S., (2012), RMVGK Rao, Studies on Mechanical Behavior of Surface Modified Sisal Fibre – Epoxy Composites, Journal of Reinforced Plastics and Composites, vol. 31, 8: pp. 519-532.

[4] Jiang A., Xi J., Wu H., (2012), Effect of Surface Treatment on The Morphology of Sisal Fibers in Sisal/Polylactic Acid Composites, Journal of Reinforced Plastics and Composites, 31: 621-630.

[5] Sever K., (2010), The Improvement of Mechanical Properties of Jute Fiber/LDPE Composites by Fiber Surface Treatment, Journal of Reinforced Plastics and Composites, vol. 29, 13: pp. 1921-1929.

[6] Mohanty S. and Nayak S.K., (2006), Mechanical and Rheological Characterization of Treated Jute-HDPE Composites with a Different Morphology, Journal of Reinforced Plastics and Composites, vol. 25, 13: pp. 1419-1439.

[7] Kushwaha P.K. and Kumar R., (2011), Influence of Chemical Treatments on The Mechanical and Water Absorption Properties of Bamboo Fiber Composites, Journal of Reinforced Plastics and Composites, Vol. 30, 1: Pp. 73-85.

[8] Anders P. S. Adamsen D. E. Akin L. L. Rigsby, (2002), Chelating Agents and Enzyme Retting of Flax, Textile Research Journal**,** vol. 72 no. 4 296-302.

[9] Bel-Berger P., Von Hoven T., Ramaswamy G.N., Kimmel L., Boylston E.,Cotton / Kenaf Fabrics: a Viable Natural Fabric, Journal of Cotton Science, Vol.3, Issue 2. 1999, p.55-65.

[10] Foulk J.A., Rho D., Alcock M.M., Ulven C. A., and Huo S., (2011), Modifications Caused by Enzyme-Retting and Their Effect on Composite Performance Advances in Materials Science and Engineering, Article ID 179023, 9 pages.

[11] W. Hu, M. Ton-That, J. Denault, D. Rho, J. Yang, and P. Lau, (2010), “Influence of Retting Process on the Thermal and Mechanical Properties of Flax-Polypropylene Composites

Made of Canadian Oilseed Flax Fibers," in Proceedings of the Polymer Processing Society 26th Annual Meeting, Banff, Canada.

[12] Foulk J.A., Chao W.Y., Akin D.E., Dodd R.B., and Layton P.A., (2004), "Enzyme-retted flax fiber and recycled polyethylene composites," Journal of Polymers and the Environment, vol. 12, no. 3, pp. 165–171.

[13] Bledzki A. K., Mamun A. A., (2010), Jaszkiewicz Adam; et al. Polypropylene composites with enzyme modified abaca fibre. Composites Science and Technology Volume: 70 Issue: 5 Pages: 854-860.

[14] Lee Sh; Wang Sq, (2006), Biodegradable Polymers/Bamboo Fiber Biocomposite with Bio-Based Coupling Agent, Composites Part A-Applied Science and Manufacturing Volume: 37 Issue: 1 Pages: 80-91.

[15] Stuart T; Liu Q; Hughes M; et al., (2006), Structural biocomposites from flax - Part I: Effect of bio-technical fibre modification on composite properties, Composites Part A-Applied Science and Manufacturing Volume: 37 Issue: 3 Pages: 393-404.

[16] Xuehong R., Gisela B.D., (2007), Oxidoreductases for Modification of Linen Fibers, Colloids and Surfaces A-Physicochemical and Engineerıng Aspects Volume: 299 Issue: 1-3 Pages: 15-21.2006.

[17] Merdan N.; Sancak E.; Kocak D.; et al., (2012), Effect of Applied Different Surface Modification Processes with Cellulose Enzyme on Properties of Luffa Fibres, Asian Journal of Chemistry Volume: 24 Issue: 3 Pages: 975-980.

[18] Gao, Y. and Ma, Y. (2004). The Performance of Hemp Fiber and Its Applications. Beijing Textile, 6: 30–31.

[19] Hu, R.-H. and Lim, J.-K. (2005). Natural Fiber Reinforced Composites and Their Applications in Automobile Industry. Proceedings of 2005 International Conference on Mechanical and Automobiles, pp. 255–260, Jeonju, Korea