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Effect of ecological surface treatment method on friction strength properties of nettle (urtica dioica) fibre yarns

S Şansal[1], S I Mıstık[2], R Fettahov[3], S Ovalı[2] and M Duman[4]
[1]Bartin University, Institute of Applied and Pure Sciences, Bartin, Turkey
[2]Marmara University, Faculty of Technology, Department of Textile Engineering, Istanbul, Turkey
[3]Bartin University Faculty of Engineering Department of Textile Engineering, Bartin, Turkey
[4]Marmara University Institute of Applied and Pure Sciences, Istanbul, Turkey
Email: imistik@marmara.edu.tr

Abstract. Over the last few decades, more attention is given to lignocellulose based fibres as reinforcement material in the polymer composites owing to the environmental pollution caused by the extensive usage of synthetic and inorganic fibres. Developing new natural fibre reinforced composites is the focus of many researches nowadays. They are made from renewable resources and they have less environmental effect in comparison to inorganic fibre reinforced composites. The interest of consumers in eco-friendly natural fibres and textiles has increased in recent years. Unlike inorganic fibres, natural fibres present light weight, high strength/density ratio and are readily available, environmentally friendly and biodegradable. Many different types of natural fibres are exploited for the production of biodegradable polymer composites. The nettle (Urtica dioica L.) is a well-known plant growing on rural sites of Europe, Asia, and North America. Nettle plant contains fibre similar to hemp and flax. However, similar to other natural fibres, nettle fibres are poorly compatible with the thermoplastic matrix of composites, due to their hydrophilic character which reduces mechanical properties of nettle fibre reinforced thermoplastics. In order to improve the fibre-matrix adhesion of the natural fibre reinforced composites, surface treatment processes are applied to the lignocellulose fibres. In this study nettle (urtica dioica) fibre yarns were treated with NaOH by using conventional, ultrasonic and microwave energy methods. After treatment processes tensile strength, elongation, friction strength and SEM observations of the nettle fibre yarns were investigated. All treatment processes were improved the tensile strength, elongation and friction strength properties of the nettle fibre yarns. Also higher tensile strength, elongation and friction strength properties were obtained from treated nettle fibre yarns which treated by using microwave energy method.

1. Introduction

Harms of the synthetic based polymers are discussed in recent years. Using of the natural materials instead of the synthetic based polymers is grooving rapidly [1, 2]. Properties of the natural fibres such as biodegradability, sustainability, good mechanical and thermal insulation properties, low density and price are increasing the usage of them [3–5].

Plant fibres are natural, recyclable, renewable, degradable and sustainable materials. However, since they are hydrophilic materials, they can easily absorb moisture and this is an undesirable characteristic as it will cause decay. Surface modification is made to facilitate the industrial use of plant fibres and thus to increase it. The surface modification made as a pre-treatment can be applied by many methods to improve the mechanical properties of the fibres, such as strength, and to increase the absorbency of the subsequent treatments by providing surface roughness, some of which are alkalization with sodium hydroxide (NaOH) [6-14] and acetylation with acetic acid [15–17]. Surface modification processes also remove as much of the structural material as lignin, hemicellulose, and pectin, allowing more reaction zones to occur in the cellulosic structure [15]. It has been observed that when the concentration of the chemical substance is too high, as well as being an important factor, it negatively affects the mechanical properties such as the strength of the fibre [14]. The most common and widely used chemical in alkalisation is sodium hydroxide.

Using of ultrasonic and microwave energy is alternative environmental friendly methods which can be used for the wet processes of the textile materials. Ultrasonic energy is occurred by rising microscopic bubbles known as cavitation [18, 19]. Microwave is a high frequency radio waves located between 30 MHz – 30.000 MHz on infrared spectrum [20]. Surface treatment process with NaOH by using ultrasonic and microwave energy methods are effective on improving the tensile strength and elongation properties cellulosic fibres such as kenaf [21].

2. Materials and Method

Nettle fibre yarns were obtained from Nepal. Nettle fibre yarns were produced by using hand spindle by local citizens of Nepal. Count of the yarns were 245 Tex.

Figure 1. Used nettle fibre yarn

Nettle fibre yarns treated with NaOH by using conventional, ultrasonic and microwave energy methods. Procedures of the conventional, ultrasonic and microwave energy methods are given in Table 1. Conventional process was performed in glass vessels. Alex brand ultrasonic bath was used for the ultrasonic method at 20 KHz frequencies. Microwave energy method was performed by using White Westinghouse brand microwave oven at a frequency of 2.45 GHz. The microwave oven was set to Medium-Low power level. The nettle fibre yarn samples were placed in sealed glass vessel and treated by the microwave energy.

Table 1. Treatment procedures of the nettle fibre yarns

Methods	Concentration of NaOH	Temperature (°C)	Duration (min)	Rinsing
Conventional	5 g/L	23	30	Distilled water
Ultrasonic	5 g/L	25	20	Distilled water
Microwave	5 g/L	60	5	Distilled water

Figure 2. Untreated and treated nettle fibre yarns

Tensile strength and elongation values of nettle fibre yarns have been tested with INSTRON 4411 testing machine (500 N load, 500 mm/min speed) according to TS EN ISO 2062 standard. Friction strength properties of the fibres have been tested by using SDL Atlas yarn friction tester. Morphological photos have been taken with JEOL JSM-T330 electron microscope in University of Marmara.

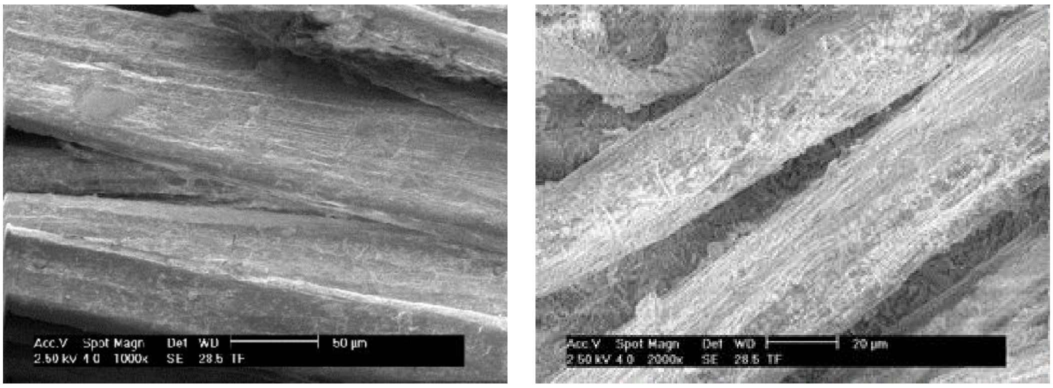
3. Results

Tensile strength, elongation and friction strength properties of the untreated and treated nettle fibre yarns are given in Table 2.

Table 2. Tensile strength, elongation and friction strength properties of the nettle fibre yarns

Samples	Tensile Strength (cN/Tex)	Elongation (%)	Friction Strength (Tour)
Untreated nettle yarn	10.4 (±1.12)	5.9 (±0,50)	80.5 (±5,18)
Nettle yarn treated by conventional method	13.1 (±1,30)	6.6 (±0,42)	90.5 (±6,06)
Nettle yarn treated by ultrasonic method	14.2 (±1,43)	6.8 (±,35)	95.6 (±5,02)
Nettle yarn treated by microwave method	16.4 (±1,25)	7.6 (±0,69)	96.4 (±5,90)

According to Table 2. after all surface treatment processes, tensile strength, elongation and friction strength properties of the nettle fibre yarns increased. Ecological ultrasonic and microwave energy methods are effective in all tensile strength, elongation and friction strength properties. The reason of that is the effect of sonication and microwave energy. The highest tensile strength, elongation and friction strength properties were obtained by microwave energy method.



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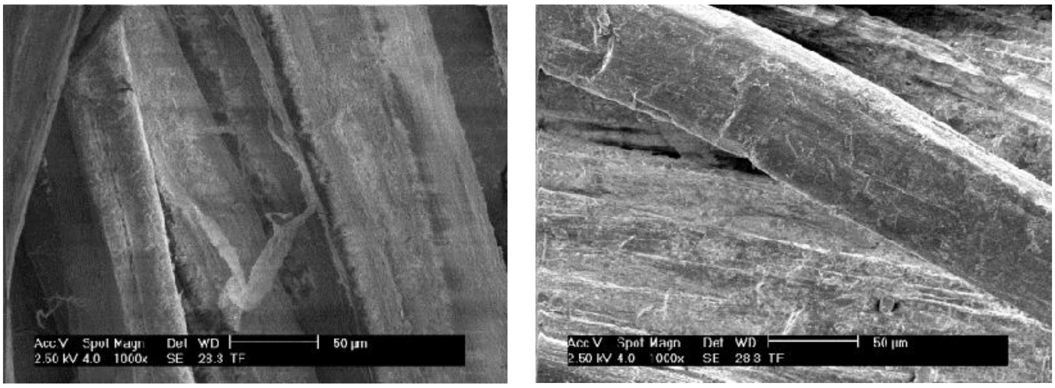

c d

Figure 3. SEM micrographs of a) untreated nettle yarn b) nettle yarn treated by conventional method c) nettle yarn treated by ultrasonic method d) nettle yarn treated by microwave method

According to the SEM micrographs of the untreated and treated nettle fibres it is seen that surface of the nettle fibres was cleaned and roughened after conventional, ultrasonic and microwave surface treatment processes.

4. Conclusion

Tensile strength, elongation and friction strength properties of the nettle fibre yarns were improved after conventional, ultrasonic and conventional surface treatment processes. Ecological ultrasonic and microwave energy methods are more effective than conventional method in all tensile strength, elongation and friction strength properties. The reason of that is the effect of sonication and microwave energy. The highest tensile strength, elongation and friction strength properties were obtained from microwave energy method. After surface treatment processes, surface of the nettle fibres was cleaned and roughened, they are now ready to be used as reinforcement material for the production of composite structures.

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