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Development of Nonwoven from *Ficus glomerata* Plant Fibres – New Beginning towards Ecological Sustainability

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A B S T R A C T

The present study deals with the development of nonwoven material using needle punching technique from *Ficus glomerata* fibres. The fibres used for development of nonwoven material were obtained from retting of *Ficus glomerata* stems and then scoured by using sodium hydroxide. The prepared nonwoven was tested for its physical properties such as fabric thickness, fabric weight, tensile strength, tearing strength, elongation, abrasion resistance and air permeability.

Introduction

In the present scenario, increasing concerns towards eco friendliness and sustainable material which leads a great demand of non-conventional fibres like jute, hemp, sisal, ramie, sunn, nettle etc.

In order to reduce the heavy dependence on cotton and silk, which are used extensively, the global industries are focusing on the new sources of natural fibres. One of the sources of natural fibres is *Ficus glomerata* species belongs to family *Moraceae*, which is locally known as ‘gular’, cluster fig tree and Indian fig tree. This plant is abundantly found in forests of Uttarakhand.

Owing to the problems of non-biodegradability, toxicity, high carbon emission and disposable problems in the production and use of synthetics materials, the development of nonwoven and fabrics such as woven and knitted from bast fibres came into existence.

Nonwoven are the structures that are manufactured by interlocking of fibres by the use of chemical, thermal, solvent and by mechanical means or their combination. The nonwoven technique has removed the process of yarn manufacturing as it is directly made from fibres. The application of nonwovens includes diapers, facial wipes, shopping bags, composites, geotextiles, filters, packaging materials, upholstery padding and in some building materials such as wall panels, carpets etc.

Needle punching is a mechanical technique of manufacturing nonwoven in which fibres are interlocked with each other by repeated insertion of barbed needles into fibrous web. It is completely a physical process, no water and chemicals are needed at all, which makes it nonpolluting.

Thus, in order to produce ecofriendly and biodegradable product, the *Ficus glomerata* fibres were utilized for producing nonwoven by using needle punching technique. The needle punched nonwoven made from *Ficus glomerata* fibres can be 100% recycled and can be reused. It can be a best green alternative in order to preserve natural environment.

Materials and Methods

Ficus glomerata plant species are used as a source of non-conventional fibres. The stems of the *Ficus glomerata* plant were cut at the time of pruning and then water retted for 21 days. After the completion of retting process, the fibres were separated from the stems and dried in shade.

In order to remove the extraneous matter from the retted fibres and to make it suitable for further use, the retted fibres were then scoured using 3% sodium hydroxide for 60 minutes. Due to the non-hazardous, non-toxic characteristics of sodium hydroxide it was used for scouring of fibres.

The scoured *Ficus glomerata* fibres were used for the preparation of needle punched nonwoven. The needle punching techniques owing to its non-polluting characteristics is utilized for production of nonwoven from *Ficus glomerata* fibres.

Process of needle punching

Needle punching loom that uses Dilo technology of Germany based on Delta card system and is synchronized with PLC (Programmable Logic Controller) drives was used for the preparation of nonwoven. This machine performs all the modern functions in a diversified manner. There are two directions of machine i.e., machine direction and cross direction which are generally used in the continuous production line starting from the feeding of fibers to the final product which is isotropic in nature. The specifications of machine consist of maximum width of 3.5 meters with a speed of 20 meters/min and the needle density was of 100 needles per linear density. To entangle the fibres directly with each other punching was done on scoured fibres web. Bonding process involves only mechanical method which includes following steps:

Carding

Carding is a mechanical process and its operation (Fig. 1) was carried out in a machine in which the fibres were opened, cleaned and disentangled. The cylinders of carding machine (Fig. 2) were covered with heavy fabric and surrounded with embedded bent wires. These bent wires on cylinders separates the fibre bundles, and removed the dust and dirt which was present in the fibres to form a uniform web.

Layering

After carding of fibres, layering was done in which the web of fibres from cards were laid one above another. Layering can be done in several ways depending on the desired weight and structure required. In the present study, cross layering method was used which consists of two different devices i.e. vertical and horizontal cross lapper. The *Ficus* *glomerata* webs were cross lapped in order to achieve increased strength, thickness and uniformity of nonwoven fabric.

Feeding of web

The cross lapped web of *Ficus glomerata* fibres, by means of web feeder were fed into the needle punching loom.

Needle punching

To achieve the structural integrity web of *Ficus glomerata* fibres were passed through a series of barbed needles placed in a needle board. The needles were arranged on a needle board in such a manner so that they release the fibres when the needle board was withdrawn. As the needle board in the machine moves up and down, the barb of needle penetrates the fibrous web, picked up fibres on downward movement and carried these fibres upward to interlock. This needle action was repeated number of times in machine which interlocked the web by frictional forces in order to achieve uniform bonded web structure.

Testing of physical properties of prepared nonwoven fabric

Physical properties such as fabric thickness, fabric weight, stiffness, air permeability, tensile and tearing strength of prepared nonwoven fabric were tested using various ASTM and ISI standard procedures.

Fabric thickness (IS: 7702-1975)

The nonwoven made from *Ficus glomerata* fibres were tested for thickness by using fabric thickness gauge. The method as given in ISI Handbook of Textile Testing (1982) was followed for determining thickness. The thicknesses were recorded on five different places of a nonwoven sample and mean was calculated.

Fabric weight (IS: 2387-1969)

Fabric weight was taken on Paramount digi Count by following ISI standard method. Fabric weight was measured in gm/m^2 and total of five observations were taken of nonwoven fabric sample and average weight was noted.

Tensile strength (IS: 1969-1968) and elongation

Tensile strength and elongation of nonwoven fabric was determined using ISI ravelled strip method. The test was repeated for five times each in machine direction (MD) and cross direction (CD) and the average was calculated.

Tearing strength (IS: 6489-1971)

The tearing strength test was carried out by using standard ISI method. The test specimens were cut with the help of template from both machine and cross directions from different portions of the sample to be tested. The reading was noted and tearing strength was calculated by using the following formula:

$$\text{Tearing Strength(gm)} = \frac{\text{Pointer reading} \times \text{capacity of instrument}}{100}$$

Fabric stiffness (IS: 6490-1971)

Fabric stiffness (bending length) of the fabric was measured as per the cantilever test method and instrument used was stiffness tester. Test specimens of 25 mm × 200 mm were cut with the help of template from both machine and cross direction.

The observations were recorded and average was calculated. The stiffness of bending length of nonwoven fabric was calculated by using following formula:

Bending length (C) = L/2 cm

Where, L = Mean length of overhanging portion in cm

Air permeability (ASTM D737)

Air permeability of *Ficus glomerata* nonwoven was determined by ASTM standard method by using air permeability tester. According to the area of the instrument the samples were cut and placed. The pressure of 5kPa was set at pressure vessel and instrument was switched on for passing the air through sample. The amount of air passed through sample was recorded from manometer in cubic centimeter. Five readings were taken in any direction of nonwoven sample and average was calculated.

Results and Discussion

Physical properties of nonwoven fabric

The nonwoven fabric prepared *Ficus glomerata* fibres by needle punching method was tested for various physical properties including fabric thickness, fabric weight, tensile strength, elongation, fabric stiffness and air permeability. The properties of nonwoven fabric are shown in Table 1 and Figure 3.

It can be concluded from Table 1 that tensile strength of *Ficus glomerata* nonwoven was 8.8 kg/cm² in machine direction and 6.72 kg/cm² in cross direction whereas elongation was 31.8 % and 23.6% respectively. It was found that tensile strength and elongation was more in machine direction than in the cross direction. This may be due to reason that *Ficus glomerata* fibres were arranged horizontally in web which increases the tensile strength and elongation in machine direction.

The above reason was justified with the study of Maity and Singha (2012); they stated that the orientation of fibres in a web has a large effect on tensile properties of nonwoven.

In the machine direction, tensile strength and elongation of nonwoven is higher because the fibres are arranged horizontally.

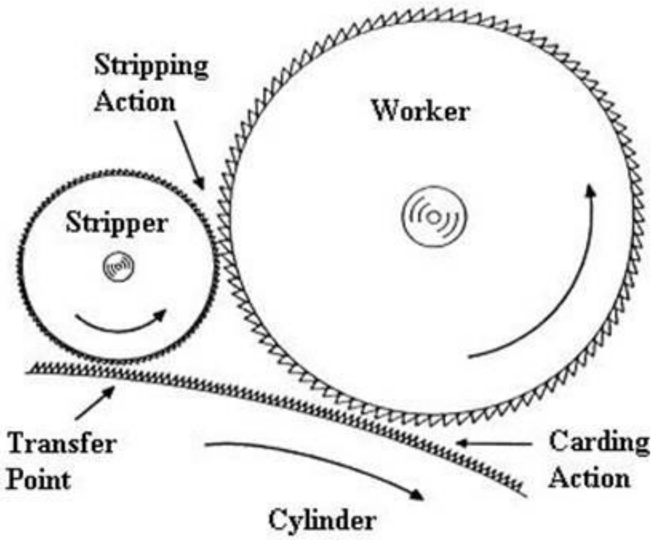
Tearing strength was found to be more in machine direction than in the cross direction. This may be due to the reason that, nonwoven produced by needle punching method had more compact structure in machine direction than in the cross direction.

It is noticeable from the Table 1 that stiffness of *Ficus glomerata* nonwoven fabric was found to be 5.2 cm in machine direction and 4.5 cm in cross direction. It was found that, the fibres in machine direction were horizontally arranged in the nonwoven web therefore; the fabric was stiffer in the machine direction whereas in the cross direction of the fabric, structure may not be so compact; therefore the nonwoven fabrics exhibited less stiffness in cross direction.

Table.1 Physical properties of *Ficus glomerata* nonwoven

S. No.	Property	Fabric direction	
		Machine Direction	Cross Direction
1.	Tensile strength (kg/cm²)	8.8	6.72
2.	Elongation (%)	31.8	23.6
3.	Tearing strength (g)	2880	2560
4.	Fabric stiffness (cm)	5.2	4.5

Fig.1 Carding action

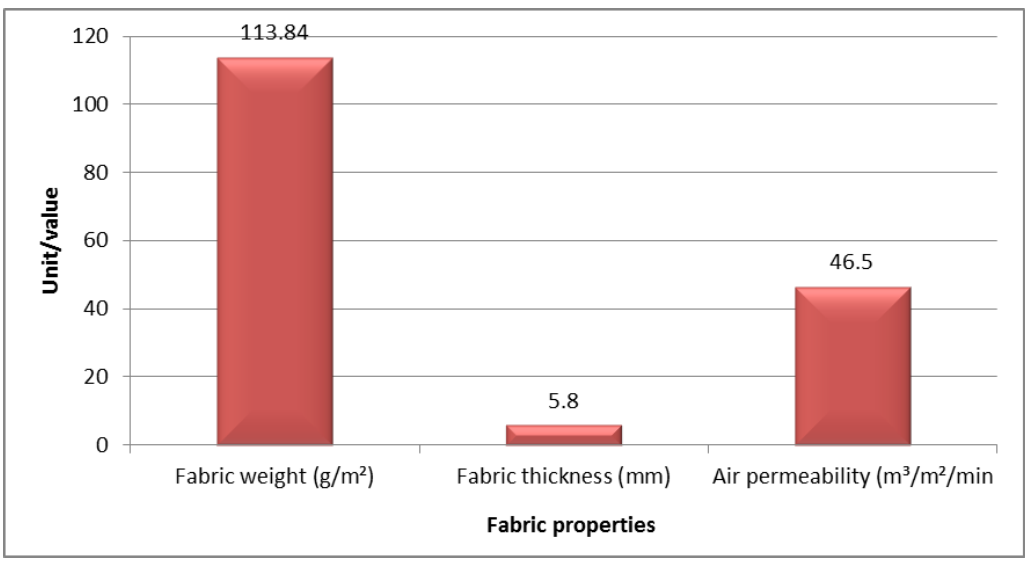


(*Source-http://fiber2fashionworld.blogspot.in/2015/02)*

Fig.2 Carding machine

(*Source- https://en.wikipedia.org/wiki/Carding)*

Fig.3 Properties of nonwoven



This is due to reason that fabric stiffness increases as the punch density increases, as the fibres are arranged vertically in web so the structures is more compact and stiff in machine direction. The above mentioned result was in accordance with the findings of Midha (2011); he reported that there was first increase in fabric stiffness with the increase in depth of needle penetration. But at higher levels of needle penetration fabric stiffness decreases due to fibre rupture.

It is evident from data in Figure 3 that the fabric weight of *Ficus glomerata* nonwoven was about 113.84 g/m^2. This leads to consequent increase in thickness of nonwoven *Ficus glomerata* fabric which was reported about 5.8 mm.

It can be envisaged from data in Figure 3 that *Ficus glomerata* nonwoven fabric made with needle punching had 46.5 $m^3/m^2/m$ average value of air permeability. This shows that the *Ficus glomerata* nonwoven had low air permeability because of the high fabric weight, highly consolidated structure and punch density. The findings of Maity *et al.,* (2012) are also in accordance with above stated reasons. They reported that there was a prominent decrease in air permeability of jute nonwoven with the increase in fabric weight and needling density.

The development of nonwoven from *Ficus glomerata* fibres is an innovative approach towards the challenges and problems that creates hindrance in ecological sustainability. Utilization of natural fibres and needle punching technique provides benefits that reduce steps in the manufacturing process of textile material, which ultimately reduces the manufacturing impact on the environment. Toxic gases which are generated during the manufacturing of fibres get eliminated with the use of natural fibres. Using those materials which occurs naturally is one way to reduce the manufacturing footprint. These are all good reasons to look towards the natural fibres as a source of raw materials for nonwoven products.

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