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Effects of Degumming on Bio - Engineering Properties of Ramie Fiber

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***Abstract*— Degumming of ramie was carried out using sodium hydroxide in such condition that varying amount of non celulosic content can be obtained on fiber. These fiber samples have been examined for bio-engineering application through wettability, microbial restivity and other properties. The fiber samples with residual gum content in the range of 2 – 6 % and sufficient lignin content can be satifactorily used in such applications.**

***Index Terms*— Bio-engineering, Chemical constitution, Degumming, Ramie**

I. Introduction

Bio – engineering textile terms mainly applied for polymeric materials used in application where it protect the erosion of soils until the nearby trees can grow up. Textiles used in the said application must have excellent filtration property along with high microbial resitivity, tensile strength, durabilty and others. Commercially wool or cotton types of natural fibers blended with polypropylene or polyethylene or polyester types of synthetic fibers are widely adopted as bio-engineering materials (1 – 3). In the application of drainage system, geotextiles should permit the water and air to flow through their structure at the same time retian the soil to move. This will prevent the erosion of soil on riverbeds or on slopes canal but simultaneously allowed the trees to grow up on other side of the water stream. The traditional ways to control erosion of soil in such areas is either heavy armour stones or concrete blocks or gabion mattresses are placed (structure). Natural textile fibers are the best substitute or formed intermediate layer in above blocks to get satisfactory effects (4, 5).

Ramie, being bast fiber has natural ability to allow water and air permaibilty alongwith excellent microbial resistivity and high wet strength (6-8). This fiber, in its raw state consist high amount of gummy materials (19 – 30 %, owf) and cannot be converted into textile fiberous forms and used. However, removal of gummy material to certain specific level, the said fiber can be explored in the areas of bio-engineering alone or in blend with oter fibers (9-12). Very few literatures avilable pertaing to the application of ramie as geo-engineering and / or bio-engineering material and most of them are patented (13,14). Gummy materials present in ramie fiber are heterogeneous in nature and removal of individual component greatly influenced on various application areas (15, 16). If raw ramie fiber pretreated in such a way that the important components of gummy materials remain in the fiber structure within specific limit, they can be satisfactorily used as bio-engineering materials. In the present research decorticated ramie fiber has been pretreated and their chemical compositions have been determined. The pretreated fibers were examined and compared for their bio-engineering applications through various properties such as microbial resitivity, strength, absorbency and others.

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II. Experimental

A. Materials

Ramie, in decorticated form (variety R – 1449) procured from the Ramir research Station, Assam, India. Long strands of fiber were cut into small lengths (ca. 10 cms) and used through out the work. All other chemicals used in the present investigation were of laboratory reagent grade. Three soils of different origin namely, canal, river band and farm field were selected for determination of bio-restivity of ramie fibers (Table – 1).

Table – 1: Specifications of soil used for bio-resistivity analysis

Property	**Soil sample**		
	Soil – 1	**Soil – 2**	**Soil – 3**
Particle size (mm)	0.015-0.019	0.036-0.040	0.005-0.01
Specific gravity	2.65	2.70	2.20
Moisture content (%)	14.2	18.6	22.4
Water permeability (cm/sc)	40	20	80
Unconfined compressive strength(kg/cm^2)	0.50-0.60	0.82-0.93	0.36-0.40

B. Pretreatment process

Decorticated ramie fiber (one gram) was pretreated (degummed) with 2 % (w/v) sodium hydroxide solution (the most commnly used) at 70°C for different time intervals (15, 45 and 120 minutes) using liquor ratio of 1 : 50 to obtain fibers with various level of residual gum content. After pretreatment fiber sample was washed thoroughly with distilled water to neutral pH.

III. Analysis

A. Determination of chemical constitution

Chemical constituents of different ramie fiber samples were determined as per the scheme prescribed by Turner and Doree (17).

B. Determination of residual gum content (RGC)

The total RGC (Residual Gum Content) on decorticated fiber was calculated from the chemical composition. The total RGC of pretreated samples, were determined from the values of weight loss of sample before and after treatment and from the values of RGC of decorticated fibers.

C. Determination of wettability

Wettability of ramie fiber before and after pretreatments was determined in terms of wicking length. In case of ramie fiber a constant weight (0.2 gm) of each sample was converted into a sliver of length 2 inches and used as a specimen for analysis. Each specimen was suspended along side of ruler scale, with its lower edge just touching the solution(congo red solution 0.05 % w/v), and the time required to travel upward in one minute was noted as wicking length. Average of three such readings were taken and reported as wettability.

D. Determination of bio-resistivity

Bio-restivity of samples was determined in terms of strength retained by the fiber after exposure to various soils for different time periods. Fiber samples were kept in specially designed chamber, filled with a particular soil, and burried for different time period (1, 2, 6 and 12 months). During this process the soil was kept wetted by spraying water (a predetermined amount) at regular time intervals. After stipulated time, the strength retention values measured through tensile strength of treated and untreated samples. Results were expressed as percentage over unexposed sample.
Degradation properties, namely, color change, fungal formation and feel were also assessed through subjective test.

If you are using *Word*, use either the Microsoft Equation Editor or the *MathType* add-on (http://www.mathtype.com) for equations in your paper (Insert | Object | Create New | Microsoft Equation *or* MathType Equation). “Float over text” should *not* be selected.

IV. Results and Discussion

A. Chemical constituents of ramie fibers

The chemical analysis of decorticated ramie indicates that the proportion of hemicellulose is the highest(15.93 %) followed by pectin (4.86 %), lignin (0.79 %) and fas and waxes (0.4 %). Pretreatment removes these non-cellulosic constituents of gummy material from ramie. The extents such removal under different degumming conditions, differ considerably. Removal of pectin, hemicellulose lignin, fats and waxes at 2 % (w/v) sodium hydroxide for 15 minutes treatment were 7, 19, 31 and 51 % respectively. With increase in duration of treatment i.e. at 120 minutes, removal of pectin, hemicellulose lignin, fats and waxes increases significantly to about 55, 90, 71 and 80 % respectively (table-2). Removal of overall gummy material increases with the severity of process conditions but the proportion of individual constituents were unequal. Extent of hydrolysis of fats and waxes were higher at initial stage and progressively increases with the severity of process. Similar trends were observed for hemicellulose and lignin. However, pectin hydrolyzed to less extent at initial stage and suddenly increased at later stage i.e. at 120 minutes duration.This may because of the heterogeneous nature of non – cellulosic impurities of ramei and their unequal distribution in the fiber strands.

Table – 2: Chemical compositions of decorticated and degummed ramie fibers

Sample Code	RNCC (% owf)	Chemical compositions (% owf)					
		HC	Pectin	Lignin	F & W	WSC	Cellulose
R – 1	27.27	15.93	4.86	0.79	0.40	5.29	72.73
R – 2	19.52	12.89	4.52	0.54	0.18	1.39	80.48
R – 3	12.62	8.14	3.13	0.43	0.14	0.78	87.38
R – 4	4.19	1.50	2.18	0.23	0.08	0.20	95.81
RNCC: Residual non-cellulosic components, HC : Hemicellulose, F & W : Fats and Waxes, WSC : Water soluble components							

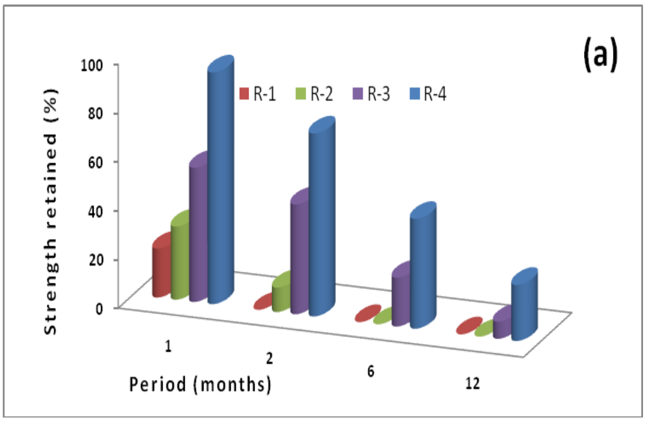
B. Microbial resistivity and wettability and of ramie fibers

In order to avail bio–engineering application of ramie fiber, it is essential to examine their microbial resitivity and wettability. Microbial resitivity was determined in different soils in terms of strength retained over untreated sample. Wettability was calculated as wicking length after removal of gummy material to various extents and also of decorticated fiber. The values of strength retained and wettabilty of different samples are reported in table – 3.
It can be seen that decorticated ramie has poor microbial resitivity compared to degummed fibers. On progressive removal of gummy material the microbial resistivity of ramie fiber increases. For e.g. in case of soil-1 (canal soil), the strength retained values were 20, 30, 55 and 95 % with the ramie fibers having gum content of 27.27, 19.52, 12.62 and 4.19 % respectively after 1 month soiling (table-3). Similar trends were observed for all the other soils for successive removal of gummy material from the fibers i.e. from R – 1 to R – 4 (table-3).

Table – 3: Microbial resistivity and wettability of ramie fibers

Sample Code	Strength Retained (%) by different soils after months												Wicking Height (mm)
	Soil – 1				Soil – 2				Soil – 3				
	1	2	6	12	1	2	6	12	1	2	6	12	
R – 1	20	D	D	D	25	D	D	D	15	D	D	D	10
R – 2	30	10	D	D	35	15	D	D	25	5	D	D	25
R – 3	55	45	20	7	60	50	25	9	50	40	20	6	48
R – 4	95	75	45	23	100	80	55	28	90	70	40	19	69
D: Decomposed													

The excellent microbial resitivity was observed for 1 month duration. However, with increase in treatment time, microbial resitivity decrease. Sample having RGC of 4.19 % (R – 4), the strength retained value after 1 month duration was almost 90 to 100 % and for 6 months duration it was in the range of 40 to 55 % and after 12 months it was between 19 to 28 % for different soil samples. One interesting point observed was that the microbial resitivity of ramie fiber sample to river soil was better followed by canal soil and farm soil. This may be due to the particular constituents present in the different soils. The microbial resitivity of various ramie fibers to different soils is more clearly compared through illustrations in figure-1.



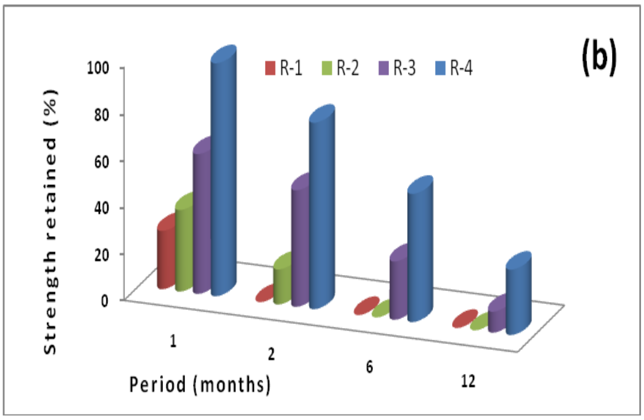


Figure 1: Microbial resistivity of different ramie fibers in (a) Soil-1, (b) Soil-2 & (c) Soil-3

It is clear that the microbial-resistivity of ramie fiber after degumming is better than that of decorticated fiber. This is because the individual constituents of non cellulosic impurities are also play important role. Hemicellulose and pectin being polysaccharide provides nutrition for microbial growth. The extent of removal of these two constituents, prevent the growth of microbial in respected level and improve bio-resitivity. Further, removal of lignin increases the fiber seperation and therefore over all crystallinity may increases. These are the probable reasons for improvement in microbial resistivity of various samples of ramie fibers.

C. Physical appearance of ramie fibers

Bio-resitivity of decorticated and degummed ramie fibers are further assessed through subjective evaluation of color change and fungal formation after soiling treatment (table-4 and 5) of various samples.

Table – 4: Subjective ratings of color change of ramie fibers after soiling

Sample Code	Rating of color change after soil treatment (month)											
	Soil – 1				Soil – 2				Soil – 3			
	1	2	6	12	1	2	6	12	1	2	6	12
R – 1	3	2	2	1	3	2	2	1	3	2	1	1
R – 2	3	3	2	1	4	3	2	1	3	3	2	1
R – 3	4	4	3	1	4	4	3	2	4	3	2	1
R – 4	5	4	3	2	5	5	4	3	5	4	4	3
Ratings : 1 – V Poor, 2 – Poor, 3 – Medium, 4 – Good, 5 – Excellent												

Table – 5: Subjective ratings of fungal formation of ramie fibers after soiling

Sample Code	Rating of fungal formation after soil treatment (month)											
	Soil – 1				Soil – 2				Soil – 3			
	1	2	6	12	1	2	6	12	1	2	6	12
R – 1	3	2	2	1	3	2	2	1	3	2	1	1
R – 2	3	3	2	1	4	3	2	1	3	2	2	1
R – 3	4	4	3	1	4	3	3	2	4	3	2	1
R – 4	5	4	3	2	5	5	4	3	5	4	4	3
Ratings : 1 – V Poor, 2 – Poor, 3 – Medium, 4 – Good, 5 – Excellent												

From the physical appearance of different ramie fibers, it has been observed that on progressive removal of non cellulosic impurities i.e. from R – 1 to R – 4, the fungal formation capacity decreases, color changes from duller to purer and feel becomes more improved. This indicates the bacteriological growth decreases with the removal gummy material from fiber. Further, with the increase in duration of soiling i.e. 1 month to 12 months the bacteriological growth increases in different fibers. The excellent feel and color retained after incubation for different time intervals was observed for R – 4 (RGC = 4.19 %) sample.

V. Conclusion

Ramie, being natural fiber can be used as bio-engineering materials. The bio-engeering behavior of ramie fiber is mainly influenced by the presence of noncellulosic constituents i.e. hemicellulse, pactin and lignin.The progressive removal of noncellulosic constituent improved bio-restivity of fiber. The removal of hemicellulose and pectin and presence of lignin increases microbial resistivity and therefore degumming should be performed in a way that level of different constituents can be mainted. The degradation of fibers examined through the color change and fungal formation also show that the removal of noncellulosic component i.e. hemicellulose and pectin increases bio-engineering application.

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