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Physical and Mechanical Properties of Flax Fiber and its Composites

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Abstract

Flax fiber (*Linum usitatissimum L*) is the natural fiber which is good in mechanical properties such as impact resistance with specific strength. Now days, natural fibers are used in various field such as aircraft industries, automobile industries and textile industries. Due to low specific weight having comparable good mechanical properties these fibers is used in these industries. Flax fiber behavior changes with the hydro and thermal conditions due to hydrophilic nature. This paper is review about change in mechanical properties due to temperature and water absorption. Dynamic Mechanical Analysis (DMA) was performed to study the evolution of the glass transition temperature in function of the water uptake for composite samples immersed in distilled water at 30°C. Flax fiber have better fatigue resistance than other natural fiber. Flax fiber stiffness evolution is found that elastic modulus may increase or decrease over fatigue life in the fiber-direction.

Keywords: Natural fiber composite • Flax fiber • Tensile strength • Thermal property • Hygro-thermal condition.

Introduction

In past years composite used due to the high specific strength and high specific stiffness and high mechanical properties [1]. Composite eliminate other material due to its physical, mechanical and thermodynamic properties [2]. Composite is more durable, non-degradable more stronger but fiber reinforced composite is stronger than other composite [3]. There are more man made polymer based composite is used but there is some disadvantage which are cost of production, high density and not biodegradable and it will be reason to health hazards [4].

An important target for the industry is to reduce its carbon footprint [5]. One way to save energy is to replace glass fibers with natural fibers such as flax [6]. Moreover the flax capability to increase the damping properties of a laminate is well known and could be interesting for increasing damage tolerance [7]. Tensile properties was enhanced when fiber were added to the polymer and has enhanced more with the use of coupling agent [8]. Flax fiber having specific strength and specific stiffness compare to other natural fiber as well as synthetic fiber. Flax fiber having various properties but there is some drawbacks [9]. These drawbacks are that fiber is hydrophilic and by the literature it observed that composite is heavily affect by the environmental change such as humidity and temperature which leads to decrease the mechanical properties of fiber reinforced composite due to swelling of fiber and matrix ageing affects [10]. Moisture absorption in fiber follow the Fick's law of diffusion (Diffusion flux is directly proportional to the negatively concentration gradient) and it helpful to determine diffusion coefficient [11]. There is suggested an approach to analysis 3D moisture diffusion parameters of glass-epoxy composites from gravimetric curves [12]. Humidity may cause damage within composites, mainly in the form of interfacial fiber/matrix micro-cracks [13]. Presence of micro-crack in composite is purely random and unpredictable [14]. Micro, cracks is main reason to propagation of crack and deformation and due to presence of moisture these micro crack propagate in the composite easily [15]. Composite strength depends on the fiber strength and modulus, matrix strength and modulus and fiber-matrix interface strength [16].

If natural fibers seem to be a particularly promising reinforcement, they also have disadvantages that need to be overcome before considering them for structural applications; the quality of natural fibers is not homogenous due to the variability of the conditions in which they are grown; natural fibers start degrading at a temperature of about 200°C, a temperature at which most thermoplastics are processed; natural fibers are hydrophilic and are therefore difficult to bond with an hydrophobic polymeric matrix and natural fibers absorb more moisture than synthetic fibers [17].

Materials and Methods

Several studies have shown that the mechanical properties of natural fibers composites are strongly affected by moisture absorption, but for

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now there is no clear understanding of the exact combination of water absorption mechanisms [18]. Strong bonds between the fibers and the matrix will maximize the mechanical performance of the composite as well as preventing the infiltration of water at the interface [19]. Fibers constituents (cellulose and hemicellulose) having high no of hydroxyl (O-H) groups in their chemical structure which leads to high polarity [20]. In some cases there is poor interface between the matrix and fiber because there nature towards water [21]. To overcome this problem by utilize hydroxyl groups in the polymerization reaction to create covalent bonds between the fibers and the matrix [22].

Flax fiber

Flax fiber exhibit highest tensile strength due to the fact that flax has the longest elementary fibers and the smallest microfibril orientation [23]. The modulus of the elementary fibers is dependent on the fiber diameter and ranges between 39 GPa-78 GPa for fibers of 35 µm-5 µm diameter [24]. This variation in tensile strength is due to the variation in lumen size of fibers [25].

The flax fiber is stiff and strong along the length due to having highly crystalline structure of the secondary cell wall [26]. Flax properties such as stiffness and strength are different in lateral direction than length direction due to direction and orientation of crystalline structure and amorphous presence [27]. Flax fiber with epoxy composites have comparable good tensile strength but having bad compressive strength [28]. The main reason of low compressive strength due to presences of kink bands (It is asymmetric, linear zone of deformation characterized by short fold limbs and very small hinge zone) [29].

To stabilize the kink bands by filling them up with melamine resin, which penetrates easily into the fibers and subsequently cross-links the fibrillar structure [30]. When melamine treated fibers which increased the compressive strength of composites, due to this treatment leads to an embrittlement of the fibers and it reduce the tensile strength of the composite [31]. Regarding the recyclability, one advantage of flax fiber composites over glass fiber composites is that they can be "thermally recycled", which means that they can be burned to produce energy without leaving large amount of residues [32].

Structure

The flax (*Linum usitatissimum*) stem is mainly composed of a wood core and a skin [33]. Technical fibers consist in 10 to 40 elementary fibers (0.1 mm-0.8 mm) that are 20 mm-50 mm long. In single flax fiber there are various layers [34].

In these layers there is a thin primary wall containing both cellulose and hemicellulose [35]. There is secondary wall which helps to strengthen the fiber and having microfibrils these microfibrils is combination of the 30 to 100 cellulose [36]. There is more cellulose in microfibrils will results higher tensile strength [37]. Flax fiber specific properties high due to the hollow core of the lumen and the orientation of the cellulose microfibrils [38] (Figures 1 and 2).

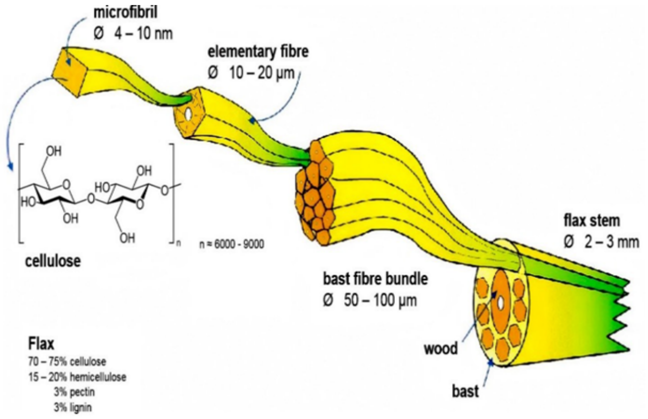

Figure 1. Flax fiber architecture

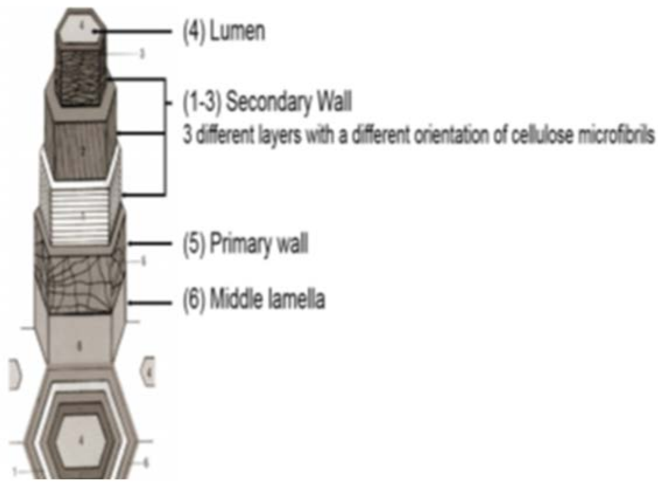

Figure 2. Flax cell structure

Factors affects the properties of fiber reinforced composite

There are various factors which affect the physical and mechanical properties of FRC.

Types of fibers: There are various natural fibers found in abundant amount in the earth [39]. These fibers are easily available. These fibers can be classified in three category on the basis of origin; plant, mineral and animal [39]. These fibers have different mechanical and physical properties such as plant fibers are very good with strength and stiffness because of containing large no of cellulose [40]. In the other hand animal fibers contain protein which leads to low strength [41]. The properties of fiber mainly depends on the chemical composition and structure of fiber [42]. The highly crystalline structure of the secondary cell wall makes the fibers stiff and strong in the longitudinal direction [43]. However, due to the orientation of the crystallites and the presence of amorphous regions between the crystallites, the cell wall properties in lateral direction both stiffness and strength are expected to differ greatly from the properties in longitudinal direction. The structure and composition depends on the various factor such as harvesting, extraction and growth period. There are different composition of flax fiber given by various authors (Tables 1 and 2) [44].

Table 1. Chemical composition of flax fibers as reported by different authors.

Cellulose (%)	Hemi-cellulose (%)	Pectin (%)	Lignin (%)	Moisture content (wt. %)
64.1	16.7	1.8	2	10
67	11	--	2	-
73.8	13.7	-	2.9	7.9
65	-	-	2.5	-

Table 2. Chemical composition of natural fibers as reported by different authors.

Fibers	Cellulose (%)	Hemicellulose (%)	Lignin (%)	Pectin (%)	Moisture (%)	Wax (%)	MFA (degree)
Hemp	70.2-74.4	17.9-22.4	3.7-5.7	0.9	6.2-12	0.8	2-6.2
Pineapple	70-82	-	5-12.7	-	11.8	14	-
Flax	64.1-71.9	16.7-20.6	2.0-2.2	1.8-2.3	44785	1.7	44691
Ramie	68.6-76.2	13.1-16.7	0.6-0.7	1.9	7.5-17	0.3	7.5
Banana	63-64	44853	5	-	44846	-	11
Cotton	82.7-90	5.7	-	0-1	7.85-8.5	0.6	-
Abaca	56-63	15-17	44751	44751	-	3	-
Jute	61-71.5	12.0-20.4	11.8-13	0.2	12.5-13.7	0.5	8
Coir	32-43	0.15-0.25	40-45	44624	8	-	30-49
Bamboo	26-43	30	21-31	-	-	-	-
Baggase	55.2	18.8	25.3	-	-	-	-

It is concluded that average composition of flax fiber is cellulose 67.47%, hemicellulose 13.8%, pectin 1.8%, lignin 2.35%, moisture content 8.95 wt.%. The comparison of chemical composition of flax fiber with some other commonly used natural fibers is presented.

There are different mechanical properties of different fibers can be listed. There are different mechanical properties of flax listed by various authors (Tables 3 and 4).

Table 3. Mechanical properties of different fibers by different authors.

Fibers	Diameter (mm)	Origin	Density (g/cm^3)	Elongation (%)	Tensile strength (MPa)	Tensile modulus (GPa)
Hemp	25-600	Stem	1.47	2.0-4.0	690	70
Pineapple	50	Leaf	1.526	2.4	17-1627	60-82
Flax	25	Stem	1.5	2.7-3.2	500-1500	27.6
Ramie	20-80	Stem	1.5	3.6-3.8	400-938	61.4-128
Banana	100-250	Leaf	0.8	2	161.8	8.5
Cotton	-	Seed	1.5-1.6	7.0-8.0	287-597	5.5-12.6
Abaca	44864	Leaf	1.5	2.9	430-813	31.1-33.6
Jute	25-250	Bast	1.3-1.49	1.16-1.5	393-800	13-26.5
Coir	150-250	Fruit	1.2	30	175	44657
Bamboo	88-125	Grass	800	1.3	441	35.9
Baggase	49	grass	-	4.03	96.24	6.42

Table 4. Physical and tensile properties of flax fibers by other authors.

Diameter (µm)	Relative density (g/cm^3)	Tensile strength (MPa)	Elastic modulus (GPa)	Strain at failure (%)
12-600	1.4-1.5	343-2000	27.6-103	1.2-3.3
10-60	1.52	840	100	1.8
10-60	1.52	1500	50	-
76 ± 16		-470 ± 165	37 ± 15	1.4 ± 0.5
17.8 ± 5.8	1.53	1339 ± 486	58 ± 15	3.27 ± 0.4
-	-	621 ± 295	51.7 ± 18	2 1.33 ± 0.56
-		600-2000	12-85	1-4
-		600-1500	50-80	1.4
-	1.4	800-1500	60-80	1.2-1.6
-	1.4–1.5	600-1100	45-100	1.5–2.4
12.9 ± 3.3	-	1111 ± 544	71.7 ± 23.3	1.7 ± 0.6
15.8 ± 4.1	-	733 ± 271	49.5 ± 3.2	1.7 ± 0.6
15.6 ± 2.3	-	741 ± 400	45.6 ± 16.7	1.7 ± 0.6
21.2 ± 6.6	-	863 ± 447	48.0 ± 20.3	2.1 ± 0.8
13.7 ± 3.7	-	899 ± 461	55.5 ± 20.9	1.7 ± 0.6
15.8 ± 4.5	-	808 ± 442	51.1 ± 15.0	1.6 ± 0.4
15 ± 0.6	1.53	1381 ± 419	71 ± 25	2.1 ± 0.8

Results and Discussion

Types of matrix used

Flax fibers reinforced thermoset, vinyl ester and polyester resins composites were also studied for determining the competitive potential of these fibers for automotive applications. Anhydride treatment is a very efficient way to improve the flax/PP adhesion and hence the mechanical properties. PLA reinforced with flax gives fully biodegradable composites, ideal for replacement of flax/PP. The enhancement of IFSS using PP/MAPP or by selecting an appropriate matrix leads to better compressive properties. The humidity sensitivity is still a problem as it decreases the long-term material properties. The properties of flax/epoxy composites are strongly influenced by the processing methods and fiber configurations.

Fiber parameters

In this fiber related parameters such as the fiber orientation, fiber length, fiber thickness, fiber-matrix adhesion, fiber treatment etc., are included. It was observed from the experimental study through various characterizations that surface pretreatments of flax fibers significantly improved the interfacial strength of the resulting composites compared to the raw flax fibers reinforced composites. There is decrease in the strength and modulus when the orientation of fiber with respect to loading is increased. The direction of fibers such as longitudinal and transverse affects the young's moduli of composite. The fiber performances and transversal modulus affects the Poisson ratio of composite. Due to high waviness ratio of fiber the change of yarn cross-section had low influence on composite performances. The ply of symmetry orientation of fiber also affects the properties of the composite such as the impact performance the composite is increased due to evenly distribution of stiffness and strength in all direction. The change in volume fraction is shows the difference between the tensile and the compressive strength for an epoxy matrix. Due to increase in volume fraction of leads to micro-buckling, because of the increase of difference in stress between the tensile and compressive modes. Shows the fiber volume fraction is main function to affect the tensile and compressive strength for flax-epoxy composite. The increase is almost linear for the two loadings and the compressive strength remains clearly lower than tensile strength. It is observed that for same volume fraction compressive strength is lower than tensile strength (Figure 3).

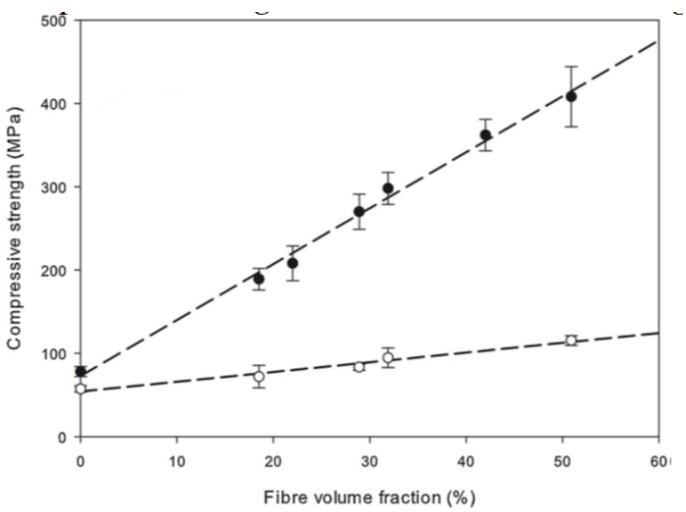

Figure 3. Flax-epoxy comparison between tensile and compressive strength as a function of fiber volume fraction. **Note:** ● Tensile, ○ Compression.

The fiber chemical treatment also affects the properties of composite such as alkali, silane and zein treatments. Alkali treatments can be used with 5%, 6% and 10% strength of NaOH solution improvement in flexural properties has been observed. The higher flexural properties can be achieved by the combination of treatment such as alkali and silane treatment.

Mechanical properties of the fiber reinforced composite

The tensile behavior of the flax fiber is depicted that it can divided in three parts. The first part is described as linear part due to an onset in the charge of the fiber. The second part is nonlinear and due variation of the angle of cellulose microfibrills in the layer which is lead to an internal reorganization of the component. The third part is strong linear which is due to disturbance in the cellulose microfibrills. According to griffith the presence of a weak link which causes the breaking of the structure is governed by the tensile strength of a fiber. Tensile strength also affects by the interaction between the fiber component and load transfer to cellulose.

Due to their low density compared to glass fibers, specific properties of plant fibers is significantly more useful.

The modulus of flax fibers depends on the fiber diameter, which ranges from 39 GPa-78 GPa for fibers of diameter 35 µm-5 µm.

Due to change in lumen size of fiber of different diameter is related to modulus of fiber. The tensile properties of flax fibers by various researchers.

Compression testing

The static Compression experiments were performed according to ASTM D695, ASTM D7336M-12 and ASTM D3410 standards by using a universal MTS-type tester, Instron 5567 [31] and H25 K-H UTM equipment.

The geometry of sample is rectangular with the aspect ratio is two. To record the displacement the displacement transducer is used.

There is study about optimization of sample shape in compression. To optimize the channel sections optimization of natural fiber composite due to high potentially due to high compression strength.

Compression strength is depends on the material used and the cross-section of the channels such as the short column has high capability to resist the compression load.

Dynamic loading experiments were conducted in a Split-Hopkinson Pressure Bar (SHPB) testing system, as shown in (Figure 4).

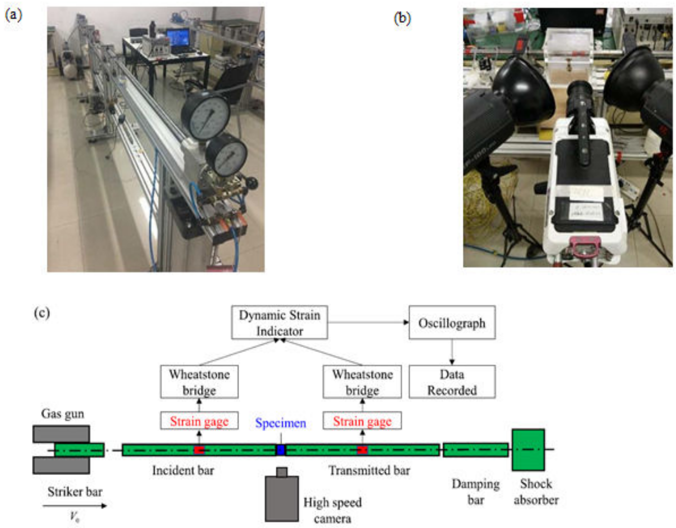

Figure 4. SHPB testing system used for dynamic compressive loading. **Note:** a: Experimental set-up; b: High-speed camera; c: Schematic of SHPB testing system.

The compressive behavior of woven flax-fiber laminated under in plane and out of plane mainly depends on the strain rate and out of plane mainly depends on strain rate compare to in plain compressive (Table 5).

Table 5. Tensile strength of flax fibers based on their position in the plant.

Location	Fiber variety	Diameter (µm)	Young's modulus (GPa)	Tensile strength (MPa)	Ultimate strain (%)
Top	Herms	19.0± 3.5	59.1 ± 17.5	1129 ± 390	1.9 ± 0.4
Middle		19.6 ± 6.7	68.2 ± 35.8	1454 ± 835	2.3 ± 0.6
Bottom		20.1 ± 4.1	46.9 ± 15.8	755 ± 384	1.6 ± 0.5
Top	Agatha	21.5 ± 5.3	51 ± 22	753 ± 353	1.8 ± 0.7
Middle		21.3 ± 6.3	57 ± 29	865 ± 413	1.8 ± 0.7
Bottom		21.3 ± 6.3	51 ± 26	783 ± 347	2.0 ± 0.9
-		19.3 ± 5.5	63 ± 36	1250 ± 700	2.3 ± 1.1

behavior. Fiber buckling and delamination transformed to shear failure with fiber fractures when strain rate increased in in-plane compressive load.

While in the out-of plane loading the shear failure take place when deformation transmitted through squeezing fiber layers.

Fatigue behavior of the fiber

In flax fiber the fatigue behavior of the composite depends on the thickness and it reduce in transverse direction of specimen. Fatigue strength increases in longitudinal direction when specimen angel is increased with respect to mold.

The fatigue life decrease in notched specimen compare to un-notched specimen. There is increase in fracture toughness when fiber is stitches in flax-epoxy composite.

This increase in fracture energies due to combined factors of higher stitch areal fraction, higher tensile loads that impregnated flax yarns (stitches) could tolerate during crack bridging and the presence of stitching-induced resin-rich areas that appeared to support more extensive matrix shear yielding [33].

Flax fiber composite absorbed higher energy before fracture in wet condition than dry conditions. It is more useful if hydrophobic fiber layer is used outside the flax fiber which prevents the flax fiber degradation and less water absorption take place which increase the fracture toughness (Figure 5).

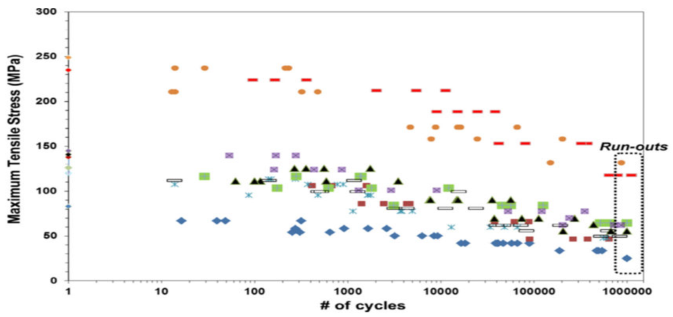

Figure 5. Stress-life data for untreated flax-epoxy composites at R=0.1 (including static strengths values).

There is study about the fiber distribution which affects the fatigue life the composite. It is described as that random fiber has lowest fatigue life compare to the quasi-UD and cross ply composite. As shown the slope of S-N curve is steeper than the quasi-UD compare to the UD and cross-ply laminates fiber. In the static test composite have high static strength for longer fatigue lifetimes. The flax composite with different weave pattern have higher stiffness and strength (due to the alignment of fiber) which lead to increase in fatigue life which can prevent the delamination and reduced the damage in composite. There is decrement in fatigue strength of composite in the middle cycle range due to high self-heating of the material. The increase in loading frequency does not affect the fatigue endurance, outside the fatigue range. Due to high tensile strength and high fatigue strength flax-epoxy composite is more useful for the structural applications (Table 6).

Effect of water absorption on the properties

Mostly Natural fibers are hydrophilic in nature compare to synthetic fiber. Natural fiber is used in various applications so that it is also necessary to study about the moisture affects the mechanical properties of composite.

Due to water absorption there is change in fiber /matrix interaction which leads to cracking the in polymer matrix in composite which is main reason of reduce the mechanical properties. Moisture damages the stress transfer efficiencies from matrix to reinforcing fiber.

Due to moisture absorption there is swelling in fiber and which degrade the fiber by stress develop between the fiber and matrix and micro cracking also develop in the interface of the fiber and matrix. Moisture absorption is a serious problem which should be treated by the chemical treatment and surface modification in the fiber. With the help of the gravimetric analysis moisture uptake can be calculated. There is type of water used is also affect the mechanical properties differently such as if fiberis placed in distilled water then it is analyzed that if fiber content is increases the absorption of water also increases and if sea water is used it directly affect the fiber/matrix interface by damaging (Table 6).

Table 6. Fatigue life curves for all configurations; expected strength values at 106 cycles.

	Fatigue life power law curves	Expected stress value atn106 cycles (MPa)
Random mat	$84.41\ x^{-0.08}$	28
Plain weave	$226.10\ x^{-0.12}$	43
Low twist twill	$175.08\ x^{-0.10}$	44
Medium twist twill	$158.25\ x^{-0.06}$	69
High twist twill	$193.37\ x^{-0.086}$	59
Quasi-UD [0,90]	$209.37\ x^{-0.088}$	62
UD [0,90]	$170.75\ x^{-0.086}$	52
Quasi-UD	$357.97\ x^{-0.074}$	129
UD	$271.36\ x^{-0.05}$	136

For the glass fibers and the flax fibers at the same fiber volume fraction of 0.40. The results of the flax fibers show a great variation whereas those of the glass fibers are relatively reproducible. In water uptake can be discussed with the capillary action. It discussed that due to non-uniform distribution of the chemical composition and diameter there is uneven swelling when fiber immersed in water. The change of flow resistance during the capillary rise due to the fiber swelling can be taken into account by modeling the ratio of permeability to hydraulic radius in terms of effective fiber volume fraction (Figure 6).

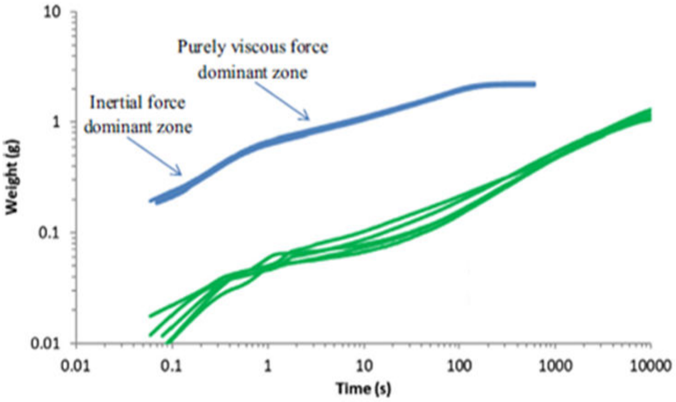

Figure 6. Capillary rise test results for glass and flax fibers with water (V_f=0.40). **Note:** Glass fibers, Flax fibers

Sometimes water uptake is also used as the treatment which also enhances the properties of fiber. In flax fiber water treatment removed the waxes and organic residues from the fiber surface and it also reduce the bond strength between pectins from middle lamella. There is reduction in the stiffness of flax fiber by weaken the components from amorphous interphase between the elementary fibers. It also help to activate the c-c bonds and which is one of the reason of surface activation and it is help to increase the interphase strength improved by water treatment.

To resist the moisture there is several treatments such as Maleic Anhydride (MA), Acetic anhydride (Ac), Silane (Si) and Styrene (S). Acetic anhydride and styrene treatments reduced water uptake of flax fibers. In terms of moisture resistance, (S) treatment appeared as the most efficient for all the water activity range. Maleic anhydride and acetic anhydride treatment affect the tensile strength is reduced but silane treatment improve the tensile properties while styrene treatment is provide good resistance to water and does not affect the tensile properties (Figure 7) [39].

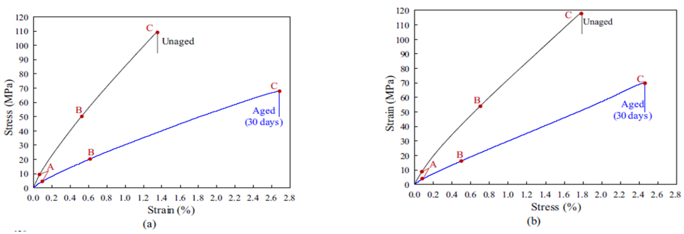

Figure 7. Stress-strain curves of unaged and aged; Flax-Epoxy; Flax-Acrylic composites loaded in the warp direction. **Note:** Unaged, Aged (30 days).

There is three parts of the graph and a-o part directly linked to elastic domain and a-b, b-c it attribute different mechanism in due to elementary flax fiber. To assess their mechanical behaviour, the aged composites were subjected to monotonic and load-unload tensile tests completed by Acoustic Emission (AE) recording. The load-unload tensile tests highlighted a decrease of about 10% of the aged composites stiffness with respect to unaged ones at high loads. The moisture diffusion is carried out only in one intended direction by water, mainly in the fibers direction. Indeed, the interaction between the water molecules, resulting from each direction, gives an easier path for the water in the fibers direction.

There is stiffness affects by the water absorbtion but it also affect by the processing of stem flax process. Due to low moisture absorption there is plasticizing effect (when small amount of plasticizer is blend with the glassy polymer) of water in flax it will initially increase the stiffness because there are water molecules in the interface between the fiber and matrix and form hydrogen bond. But as amount of water absoption increase there is aggregation of water take place which reduce the plasticizing effect which leads to decrease the stiffness (Figure 8).

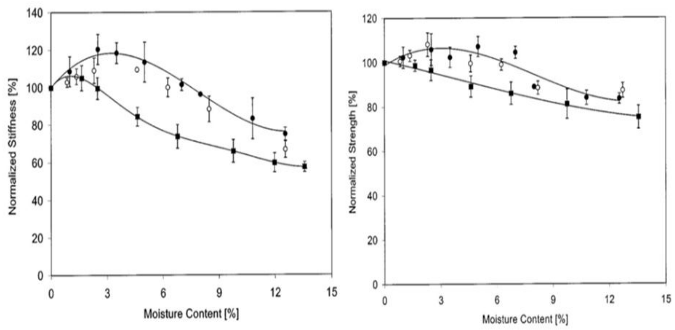

Figure 8. Effect of moisture content on the stiffness and tensile strength of green flax/polypropylene, duralin flax/PP and duralin flax/ maleic anhydride modified polypropylene (non-woven mat, film stacking). **Note:** ▪ Green flax/PP, **O** Duration/PP,● Duralin/MA-PP.

Thermal properties of fiber reinforced composite

Thermal stability is important parameter which affects the composite performance. The natural properties and the various constituents of plant fibers can generate poor composite performance due to thermal degradation. The thermal degradation of plant fiber depends on a number of factors namely, chemical composition of materials, temperature and heating rate. The adherences of the composite decreases and degree of depoymerisation increases with increase in temperature. This decrement in the tenacity of composite with increase in dwell time at high temperature due to chain scission. For flax fiber at 170ºC for 120 minutes and at 2000ºC for 30 minutes fiber retain its strength. Due to increase in temperature there is increase in polymer mobility which leads to decrease the storage modulus. This storage modulus can be increased with the help of the hybrid composite means when other fiber such as basalt fiber used with flax fiber it also increase the stiffness of the composite.

The peak of tan delta increase with increase in fiber content upto certain amount and it decreases with increase in fiber (Figure 9).

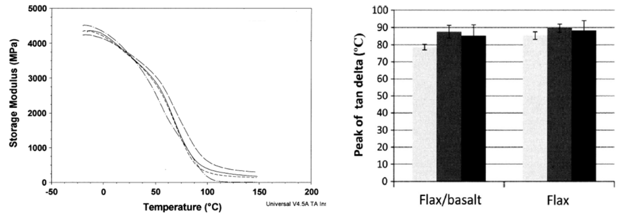

Figure 9. Storage Modulus and peak of tan delta comparison of the composite. **Note:** 40%, 50%, 60%.

Thermo gravimetric analysis

In the case of flax composite, there was just a slight difference in the loss of weight from the samples, irrespective of the fiber load because the different weight fraction 40 wt.%, 50 wt.% and 60 wt.% lost about 46 wt.%, 41 wt.% and 45 wt.% of their sample weight at maximum degradation point. The degradation temperature of flax composite was lower than that of flax/basalt hybrid composite due to higher amount of lignocellulose content in flax fiber composite (Figures 10 and 11).

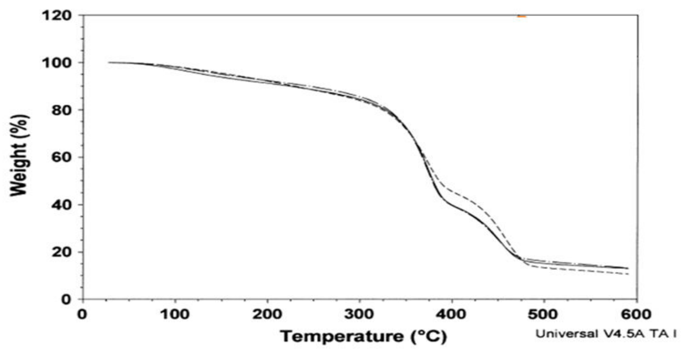

Figure 10. TGA curve of flax composite with different fiber load. **Note:** B 40%; B 50%; B 60%.

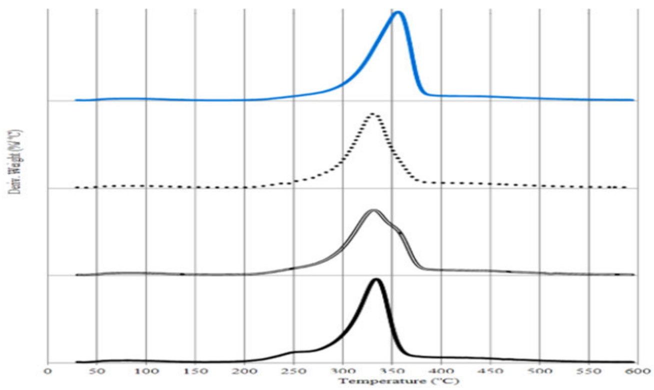

Figure 11. TGA curve of flax composite with different treatment.

Note: 5% Treatment, ... 3% Treatment, 1% Treatment, Untreated Fibers.

The thermal properties of the fiber can be increased with the help of the fiber treatment such as alkaline treatment. The effect of alkaline treatment on the DIfferential Thermo-Gravimetric (DTG) peak position. Initially due to mass loass of water low peak, in the range of 40°C to 150°C.Untreated fiber s how small s houlder peak between 239°C to 260°C which is due to thermal degradation of the hemicellulose and pectin. With the alkaline treatment the differential thermo-gravimetric peak can be shifted to higher temperature. This shifting depends on the concentration of NaOH solution because at higher temperature low thermal stability of hemicellulose and pectin which is removed with help of alkali treatment.

Conclusion

Flax fibers are completely different from synthetic fibers in terms of physical and chemical properties. In order to achieve high-quality composites, their processing behaviour and especially their interaction with polymeric resin systems need to be understood. The hydrophilic nature of flax fibers leads to a high water uptake in the composite, inducing a significant loss in all mechanical properties. It is a major obstacle for the development of natural fiber composites. Furthermore, matrix properties have a direct influence on the mechanical behaviour and on the interface quality of flax fiber reinforced composites. Natural fibers also swell when absorbing moisture, which can increase the degradation rate of the interface. Most studies only determine the maximum water uptake and very few of them show the evolution of the mechanical properties during ageing. The emphasis of many of these reports is related to the drop in the mechanical performance. A better understanding of how the fiber/matrix adhesion is affected by the polymer properties could help developing resin systems with high natural fiber compatibility. It concluded that, the evolution of the interface during ageing and how it can be improved by using functionalized polymers, has a direct impact on the quality and performance of this type of composites.

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