A REVIEW ON THE PHYSIO-MECHANICAL BEHAVIOR OF HIMALAYAN NATURAL FIBER-REINFORCED POLYMER COMPOSITES WITH SINGLE STACKING OF SINGLE FIBER MAT USING BAUHINIA VAHLII, NETTLE, KENAF AND GREWIA-OPTIVA

[1]Bhanu Pratap, [2]Vinay Kumar Patel, [3]Hemant Kumar, [4]Chandraveer Singh

[1,2,3,4]Assistant Professor

[1]Department of Mechanical Engineering.

[1]G.B.Pant Institute of Engineering and Technology, Ghurdauri Pauri Garhwal, Uttarakhand India.

Abstract : Over a decade, long used traditional plastics, ceramics, metals and their alloys are used engineering because of their properties. But over last decade years a newly invented materials that composites have seen a rapid growth in replacing the long used traditional materials. The applications and usage of composite materials has grown exponentially and is infiltrating the industry and achieving elevations the new composite materials are giving a significant number of engineered materials ranging from industrial applications to daily products applications. This review comprises of study of composite with investigation of Physio-Mechanical behavior of polyester composite with the use of four different fibers namely Bauhinia vahlii fiber, Nettle Fiber, Kenaf fiber and Grewia-Optiva Fiber (Himalayan Bhimal) at different fiber loading. Further analysis of the composite will reveal the adhesion property of fibers mats with epoxy, hardness, and morphological analysis, tensile, flexural analysis, effect of fiber loading on void fraction, and their density.

***IndexTerms* - Natural fiber, epoxy resin Bio composites, green composites, fiber mat stacking.**

INTRODUCTION:

Recently, the demand of the fiber-based polymer composites continuously increases because of the unique high performance and processing benefits at genuine costs by addition of different fibers in thermosets and thermoplastics [1]. Fiber reinforced polymer composites having their unique properties possess high specific strength and stiffness, resistance to high damage, good fatigue strength, and low expansions in thermal conditions. Due to environmental concerns which are increasing day by day there is a general shift in trend to increase the use of sustainable materials and reduce the long used synthetic fibers. In comparison to these changing trends fibers such as jute, sisal, hemp, flax, ramie, Bhimal are showing potential with acceptable strengths low density, multi functionality, good thermal properties and low abrasionand wear properties. The chemical and physical composition of natural fibers are mainly determined by physio-mechanical properties of natural fibers, such as the cellulose content, fiber angle, cross section of fiber structure, and degree of polymerization. Moisture absorption is the main cause of degrading the properties of natural fibers, this may be due to weak bonding occur due to swelling of fibers resulted that weak interfacial adhesion between fiber and matrix constituents [2]. Recognizing the facts, the main aim of the present study is to characterize the mechanical and thermal behavior of bidirectional- natural fiber mats in order to use as reinforcing agents for structural composite materials. Different fiber mats were made and were hybridized and stacked together, in order to gain best hybrid reinforcement materials

Therefore, the evolution of polymer composite materials from aerospace to other industrial and commercial uses has become enhance in recent years. Effectively enabled by the introduction of new and different types of polymer based resins and epoxy's and high performance reinforcements such as carbon fibers, aramid fibers, glass fibers etc. The increased use of these materials has resulted in cost reduction and high performance. These FRP's can now be seen in a number of applications such as composite armor designing and manufacturing, chassis and body designing, roll cage designing, wind mill blades, industrials drive shafts, support beams for civil constructions and many more. However, with different applications different types of composites have been developed and structured classes of composites have been defined according to their work areas. Further the need of composites for lighter constructions materials and more seismic resistant structures has placed high emphasis. Basically a composite consist of a matrix phase and dispersed phase. The matrix phase is a bulk phase which is continuous and other is the dispersed phase also called as reinforcement phase, which is non continuous and is much harder and stronger and provide strength to matrix.

Both thermosets and thermoplastics are attractive as matrix materials for composites. In thermosets composites formulation is complex due to involvement of base resin, curing agent, catalyst, flowing agents and hardeners. Thus the key issues in the development of these fibers composites are

- Thermal stability of fibers.
- Surface adhesion characteristics of fibers
- Dispersions of fibers in case of thermoplastics composites.
- Fiber Reinforced Composites
- Short Fiber Reinforced Composites
- The most common type of fiber used in thermoplastic is glass fiber and carbon. Addition of short fiber to resins improves the performance and makes them cheaper and cost effective.
- They are further divided into two types
- Random orientations of fibers in composites
- Definite/preferred orientation of fibers in composites.
- Long Fiber Reinforced Composites
- In this type of composite material, reinforcing fiber agent is present in long and continuous form in matrix phase of composite and classified in two parts i.e.
- Single or unidirectional orientation of fibers.
- Two or bidirectional orientation of fibers.
- Particle Reinforced Composites
- In this type of composites, matrix is reinforced by different fiber in particle form with variation of particle size. These are one of the cheapest and most widely used type's composites systems. Depending upon the size of the particle they come under two categories.
- Composites with randomly oriented particles.
- Composites with preferred oriented particles

MATERIALS AND METHODS

BAUHINIA VAHLII (phanera vahlii)

The bauhinia vahlii fiber was used in mat form and was extracted from the local meadows of Pauri Garhwal region. The fiber was extracted as a bast fiber from the stems of the plants. The fiber surface was modified by using sodium bi carbonate treatment and alkali treatment in order to remove all the cellulosic contents such as pectin, wax, lignin, and hemi cellulose. The effect of these treatment was confirmed through the FTIR (Fourier Transform Infrared Spectroscopy) analysis. The peaks were analyzed in the infrared spectrum to indicate the presence of bonds in the fibers. The fibers were woven to a mat form in longitudinal and latitudinal directions and were stacked with other fiber mats for further analysis.

HIMALAYAN BHIMAL (Grewia- Optiva)

Grewia- optiva is a hilly region tree (13-15m of height) which is finding abundantly in Himalayan region of Nepal and India. This is multifunctional tree and used in various purposes; fodder to animals, fuels wood, hair cleaner shampoo, for making ropes, boots, baskets, also herbal remedies etc. The Grewia- optiva fibers can be extracted by using physical water retting method which is eco-friendly and very cost effective. The enzymatic action of bacteria in water helps in removing all the fiber impurity such as pectin, cellulose and wax. Moreover, shoots of Grewia- optiva is soaked in river or pond for long duration to remove all unwanted chemical impurities and finally it is taken out and beaten by stone for achieving the fiber from shoots [4]. The achieved fibers are then dried in sun shades and used for preparing different articles. Further chemical treatment is done NaOH solution which helps to clear all the impurity from the fibers.

NETTLE FIBER (urtica dioica)

Nettle commonly known as sting nettle and locally known as kandali/ Bichoo Ghas in the Garhwal region. Nettle fiber favors high cellulose contents and the tenacity are favorable properties. These fibers have been prominently used from the ancient times to make ropes and textiles. The fiber was extracted from the Pauri region and were subjected to chemical treatment for removal of cellulosic contents. The extraction method plays an important role for fiber properties. Further surface modifications improved the fiber matrix interphase resulting in enhanced mechanical strengths and stiffness. Nettle fiber extraction at Nano cellulosic level may increase the diversification in the application area of nettle fibers.

KENAF FIBER (hibiscus Cannabinus)

Kenaf fiber is one of the most used fibers which belong to the bast fiber category and mainly utilized for the paper and rope production. They are rigid, and have high resistance to insect infestation. The fibers are extracted from the stems, outer and inner core. The outer core contains the bast fiber which make the 40 percent of dry weight and inner core comprises 60 percent. The fibers are extracted using a mechanical separator, the extracted fibers are chemically treated in order to remove all the impurities present. The fiber can be further weaved to a mat form, non-woven forms and utilized to the best. Further modification will promote the better strength and adhesion when stacked in single fiber or double mat with other fiber mats.

CHEMICAL PROPERTIE'S OF VARIOUS FIBERS

Table 1. Chemical Properties of Different Plant Fibers [3]

Fiber type	Cellulose [%]	Lignin [%]	Hemi-cellulose [%]	Pectin [%]	Wax [%]	Ash [%]	Microfibrillar angle[%]
Abaca	53-60	7-9	20-25	-	3	-	20-25
Bamboo	26-43	1-31	30	-	10	-	-
Banana	63-83	5	-	-	11	-	11-12
Coconut coir	36-43	0.15-0.25	41-45	3-4	-	-	30-49
Cotton	83-91	-	3	0.6	8-9	-	-
Flax	64-72	2-2.2	64-72	1.8-2.3	-	-	5-10
Hemp	70-74	3.7-5.7	0.9	0.8	1.2-6.2	0.8	2-6.2
Jute	61-72	12-13	18-22	0.2	0.5	0.5-2	8
Kenaf	45-57	22	8-13	0.6	0.8	2-5	2-6.2
Nettle	86	4.0	5.4	0.6	3.1	-	-
Rachis	43	26	-	-	-	-	28-37
Ramie	69-91	0.4-0.7	5-15	1.9	-	-	69-83
Rice husk	38-45	-	-	-	-	20	-
Sisal	78	8	10	-	2	1	-
Hard wood	43-47	25-35	-	-	-	-	-
Softwood	40-44	25-29	-	-	-	-	-

CHEMICAL TREATMENTS OF FIBERS:

After a several benefits of natural fibers, it is attaining some demerits are poor stability and high water uptake capacity resulted that poor adhesion between fibers and matrix. The main constituents of natural fibers are cellulose, hemicelluloses, lignin, pectin, and wax. But cellulose is the major constituent of the configuration providing high stability, stiffness, and strength of the fibers [3]. The mere subjection ofplant fibers to different chemical treatment can lead to removal of all the impurities present at the surface of the fiber. Removal of impurity will result in the better adhesion property and good bonding and provide better strength. Many types of surface treatment are done in order to partiallyimprove the bonding characteristics such as:

- Alkali treatment
- Benzoylation treatment
- Silane treatment
- Alkali treatment
- Potassium permanganate treatment
- Oxidation treatment

MECHANICAL PROPERTIES OF DIFFERENT NATURAL FIBERS:

Table 2. Mechanical Properties of Different Natural Fibers [3]

Fiber Type	Density (gm/cm^2)	Tensile strength (MPa)	Specific Strength (MPa)	Young's Modulus (G Pa)	Specific Moduls (G Pa)	Elongation (%)	Specific Gravity
Flax	1.4	340-1600	535-1000	25-81	16.7-54	1.1-3.3	1.5
Hemp	1.48	550-900	372-608	70	-	0.8-3	1.5
Ramie	1.5	200-1000	147-625	41-130	27-81	1.5-4	1.6
Kenaf	1.2	223-1191	641	11-60	10-42.9	1.6-4.3	1.3
Jute	1.46	385-850	269-548	9-31	6.9-20.7	1.4-2.1	1.3-1.5
Leaf	-	-	-	-	-	-	-
Sisal	1.33	400-700	366-441	8.5-40	6.5-30.8	1.9-1.5	1.3
Abaca	1.5	980	-	-	-	-	-
Fruit	-	-	-	-	-	-	-
Coir	1.25	170-230	146	3.0-7.0	2.5-5.0	14-30	1.2-1.4
Banana	1.35	711-789	444	4.0-32.7	3.6-273	2.4-3.5	1.1-1.2
Betelnut	0.2-0.4	120-166	-	1.3-2.6	1.0-1.9	22-24	1.3-1.4
Stalk	-	-	-	-	-	-	-
Wheat	1.45	-	-	-	-	-	-
Grass	-	-	-	-	-	-	-
Elephant	0.817	185	-	7.4	-	3	-
Sea	1.5	453-692	-	3.1-3.7	-	13-26.6	-
Cane	-	-	-	-	-	-	-
Bagasse	1.5	170-350	-	51.6.2	3.6-4.1	6.3-7.9	1.4-1.5
Bamboo	1.1	500-575	454	27-40	50-67.9	1.9-3.2	0.4-0.8

Natural Fiber Plants:

The figure below shows the important plants which provide the wonderful fibers for natural composite fabrication.

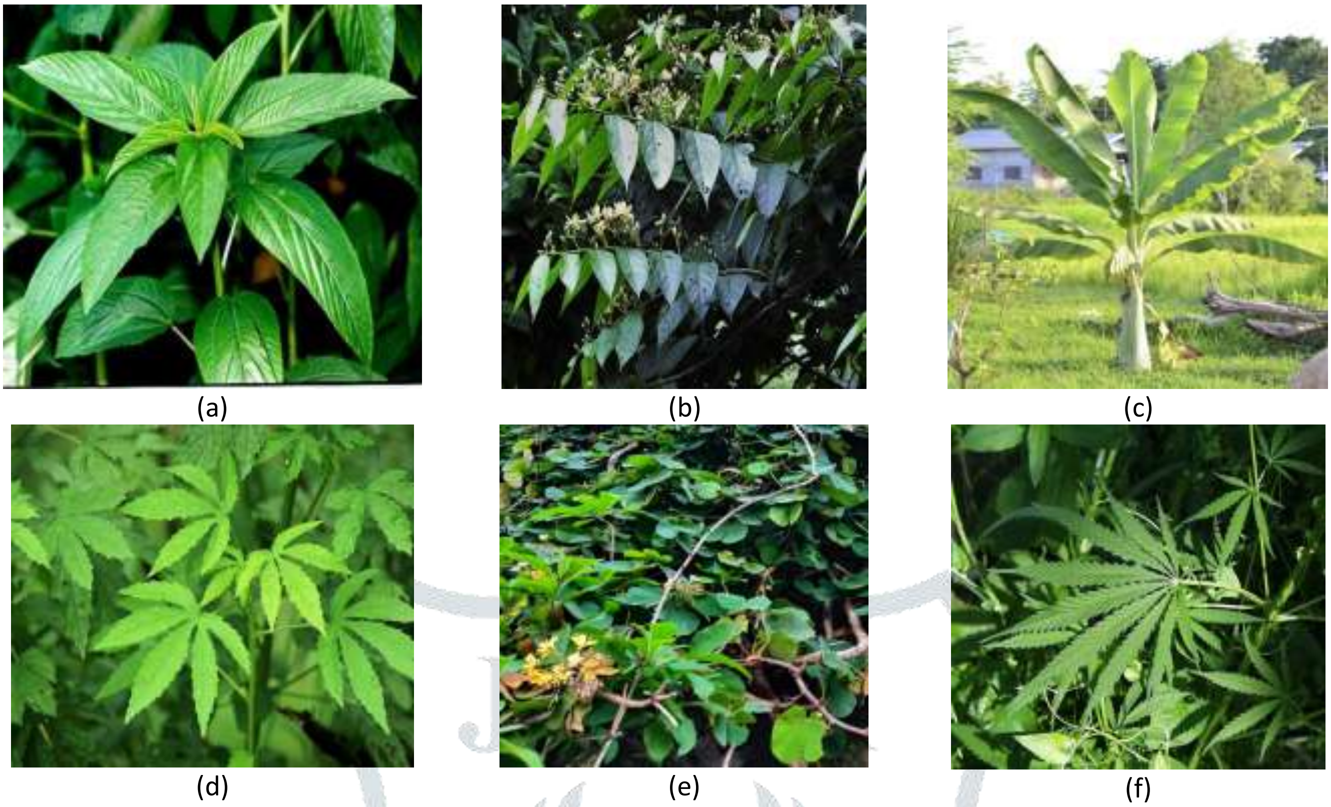

Figure 1: (a) Ramie Plant, (b) Gravia Optiva plant, (c) Bannana Plant, (d) Hemp plant, (e) Bahuhinia Vahlii and (f) Flax plant.

FIBER MATS

Fiber Mats after extraction of fibers and chemical treatment.

Figure 2 Nettle fiber Mat

Figure 3 Kneaf Fiber Mat

Figure 4 Bauhinia Fiber Mat

Figure 5 Grewia Optiva Fiber Mat

FOURIER TRANSFORM INFRARED SPECTROSCOPY:

The FTIR bands for characteristics chemical groups of lingo cellulosic fibers composition (cellulose hemicelluloses and lignin) can be detected in the graphs. Finally, observed that the characteristics of the hydroxyl groups (OH) available in the cellulose, water, lignin structures [2]. A broad absorption band in the range of 2500-4000 cm^{-1} shows the presence of single bond. the range may, if the spectrum range is between 3650-3250cm^{-1}, it indicates the presence of H bond. This confirms the presence of H2O. Similarly the range between 2000-2500 confirms the triple bonds and range of 1500 – 2000 confirms the double bond similarly the range of 600-1500 indicates the fingerprint region.

FTIR analysis of Grewia- Optiva Fiber.

Graph reveals the FTIR analysis of GO fiber. The results can be calculated as follows.

- Regarding the number of peaks, there more than 6 peaks in spectrum. Broad absorption band was found indicating the presence of H bonds in the fiber.
- Spectrum revealed a sharp peaks at range from 2000 cm^{-1} to 2400 cm^{-1} , indicating the existence of oxygen relating bonding.
- No peaks were found between 4000-2500 informing there is no aromatic structure.
- Triple bond region between 2500-2000 cm^{-1} indicated the presence of carbon triple bonds.
- Huge sharp peak was observed for at about 1700-1800 cm^{-1} , indicating the presence of carbonyl double bond groups , which can be in the form of either the aldehydes , esters, or carboxyl's.

- Large peaks were observed between the 450- 600 cm^{-1} region indicating the presence of finger print region. Indicating the presence of poly sulfides, aryl disulfides, and thiols and thiol substituted compounds.

FTIR analysis of Bagasse Fiber.

Graph reveals the FTIR analysis of GO fiber. The results can be calculated as follows.

- Regarding the number of peaks, there are less than 7 peaks in spectrum. Broad absorption band was found indicating the presence of H bonds in the fiber.
- Spectrum revealed a sharp peaks at range from 2000 cm^{-1} to 2400 cm^{-1} , Indicating the existence of oxygen relating bonding.
- No peaks were found between 4000-2500 cm^{-1} informing there is no aromatic structure.
- No sharp peak was observed for at about 1700-1800 $cm^{-1.}$
- Large peaks were observed between the 450- 500 cm^{-1} region showing the finger print region. And indicating the presence of poly sulfides, aryl disulfides, and thiols and thiol substituted compounds.

The difference in the intensities between bagasse and Grewia- optiva fiber is obtained by FTIR analysis. Realized from the spectrum of the both fibers, the bands are more actuated and it can be observed a large exposition of cellulose and moisture on fiber surface. It is obviously seen that more than 70% of wt% of natural fiber are made up of cellulose. For making the fiber as a reinforcing agent, it is compulsory to remove the cellulose from the fiber, and then preparing the fiber reinforced polymer composites.

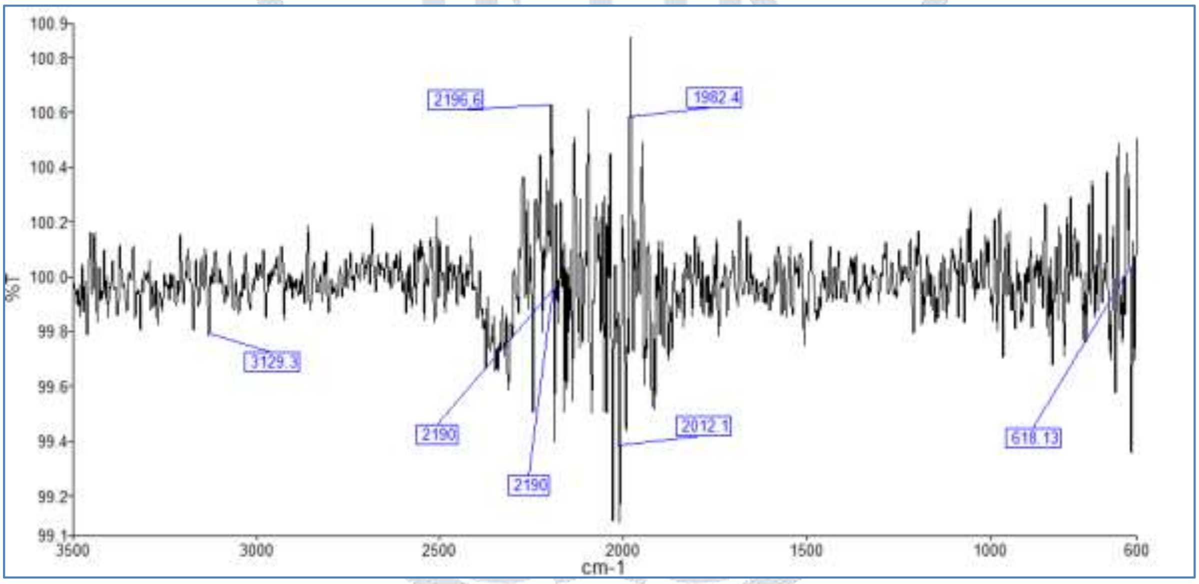

Figure 6. FTIR of Bauhinia Vahlii.

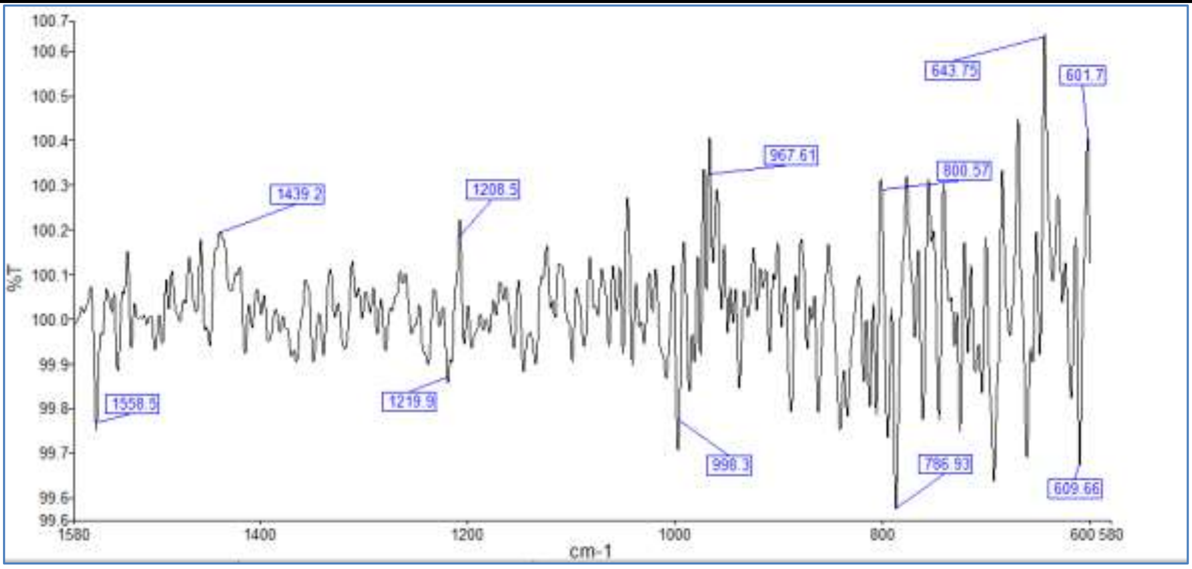

Figure 6. FTIR of Kenaf Fiber

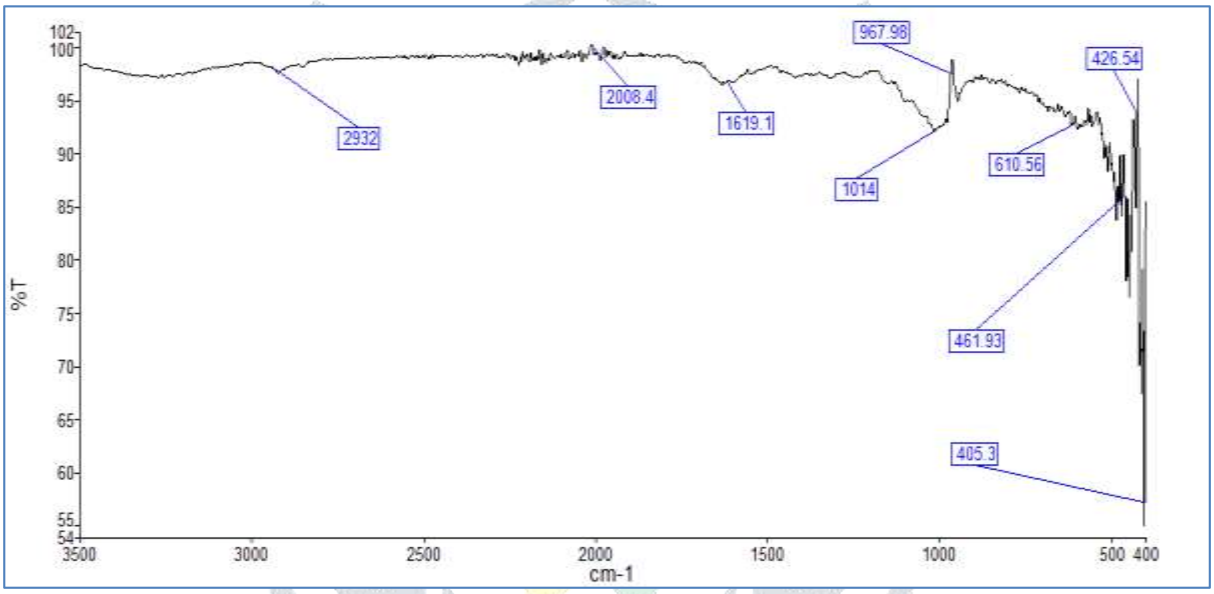

Figure 13. FTIR of Nettle Fiber

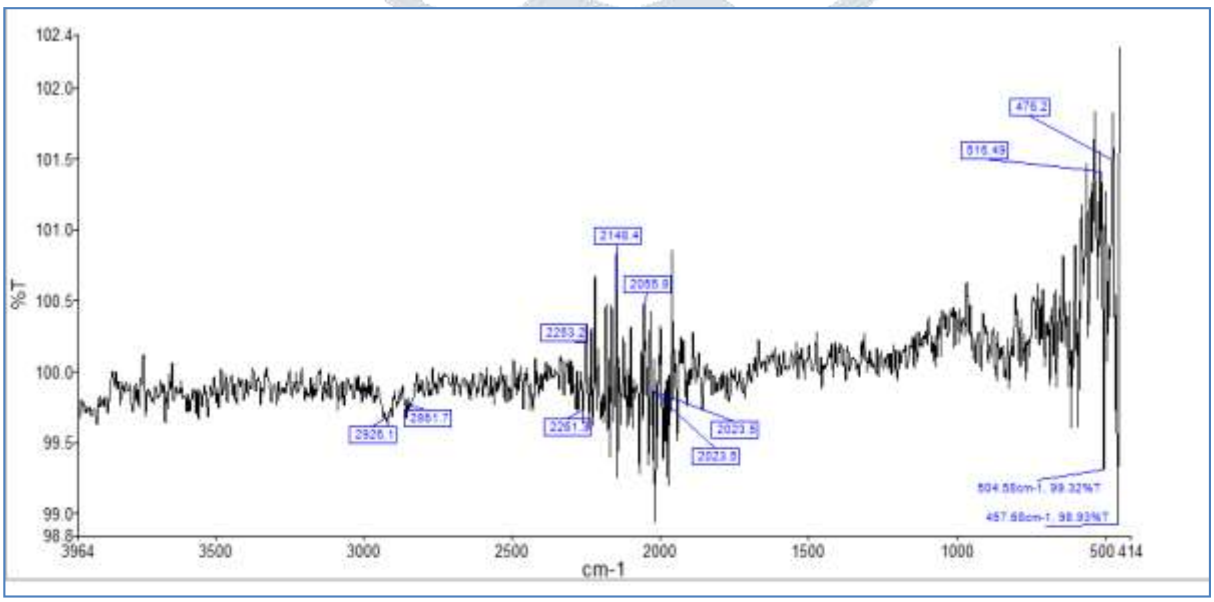

Figure 14. FTIR of Grewia- Optiva Fiber

APPLICATIONS:

Automotive and aircraft industries are using these natural fibers for replacing the different synthetic fibers. These fibers can be utilized to best of potential such as insulating materials, interior components, architecture. The availability of natural fiber in India, provide an opportunity towards the fabrication of composites by natural fiber primarily to investigate value-added application avenue [3]. Big automobile companies such as Mercedes, Audi, Bmw, and many others giants are using these natural fibers to make degradable parts and components. These fibers are further used in making ropes, cords, dashboards, furniture etc. It is essential to encourage the use of natural fibers as reinforcing agent in polymer to make Nano as well as bio composites to some extent. The accurate degradation of the plastics must be a better way to avoid the hazardous influence on the environment.

CONCLUSION:

The present review has been presented, with an aim to measure the potential of the different fiber polymer composites when used in multiple stacking and to study the mechanical behavior of composites. Study revealed that when fiber was used in mat form there was a increment in overall mechanical and bonding properties of the fabricated composites. The natural fibers are the future materials which are capable of replacing the current materials, however a lot of improvement and is required in order to remove the poor moisture resistance and incompatible nature. Therefore, thereis a need to study and develop new methods to enhance these disadvantages and increase the advantages. In near future the natural fibers will play a major role in development of renewable resources in the composite field which will be able to replace the synthetic fibers in long run[5].

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