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# A STUDY ON NATURAL FIBER POLYMER COMPOSITE

**Amrinder Singh[1] and Amrinder Pal Singh[2]**

[1] *Mechanical Department UIET PanjabUniversiy, Chandigarh,*
*Email: amrinder_Sekhon4@yahoo.com*
[2] *Mechaniaca Department UIET Panjab University Chandigarh, India,*
*Email: apsingh@pu.ac.in*

***Abstract:*** NFPC are the materials prepared by the use of polymer matrix and natural fibers as reinforcement. The properties of NFPC like biodegradability, environment friendly, abundant availability, non-abrasiveness, renewable, high specific properties, ease of manufacturing, light weight etc. makes it a material which can be used for many engineering applications. Literature suggests that the mechanical response of NFPC is comparable to GFPC. NFPC being biodegradable and containing natural reinforcement makes it a better alternative to manmade fiber.

***Keywords:*** Natural Fiber, composite, mechanical characterization, compression moulding, injection moulding.

## 1. INTRODUCTION

The word composite means “Made from several recognizable elements” and in the same sense composite material is a material made from two or more constituent materials with significantly different physical or chemical properties. Combining them produces a material having different characteristics than the individual components. Composites generally are made of two materials/phases known as the Matrix material working as continuous phase and Reinforcement working as the discontinuous phase. Composite materials possess properties like low specific gravity, high strength to weight ratio, higher stiffness, cost effectiveness, better surface properties, good reproductively etc. which makes these material widely applicable in aerospace engineering, automobile engineering, structural engineering, sports etc.Polymer matrix needs reinforcement to improve the strength and stiffness of the resulting composite. Generally the matrix is weaker in load bearing then the reinforcement in PMCs.

Better adhesion between fiber and reinforcement improves load sharing of both the phases. PMCs can be fabricated having better strength, improved stiffness, resistance to corrosion, low cost using simple manufacturing techniques. Thermoplastic and thermosetting polymers are used as matrix materials to make PMCs. Both natural and manmade reinforcements in the form of fibers, whiskers, particulates, fabrics etc. can be used to make the composites.

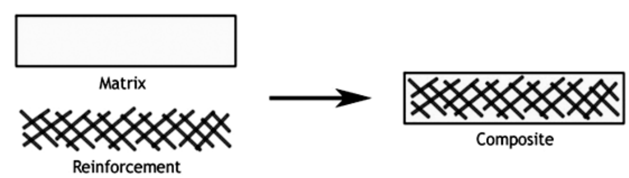


**Figure 1: Schematic diagram for understanding about Reinforcement and Matrix in composite.**

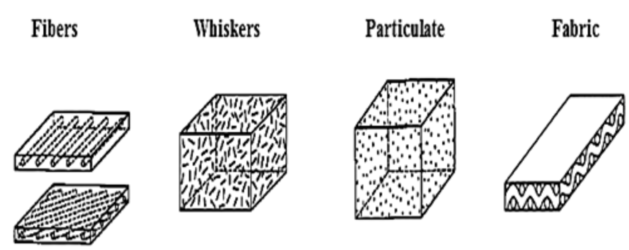


**Figure 2: Schematic figure for understanding about Various distributions of fibers in polymer matrix.**

Natural fibers are preferred as filler materials in polymer matrix due to their light weight,

**Figure 3: Components prepared from Natural fiber polymer composites.**

reasonable strength & stiffness, weight-specific performance, non-toxic nature, ease of processing, low cost etc.Due to environment concerns like recyclability and biodegradability, these reinforcements are an eco-friendly alternative to the man-made fibers [3].

But there are several problems in working with natural fibers as reinforcement in polymer matrices due to their hydrophilic nature, poor adhesion between fiber and matrix, randomly oriented fiber structure etc. These problems can be addressed by various chemical fiber treatments like alkaline treatment, silane treatment, acetylation treatment, stearic acid treatment, permanganate treatment, triazine treatment, fatty acid derivate treatment, fungal treatment of the fibers [4].

## 2. LITERATURE REVIEW

The mechanical properties of kenaf fiber composites are comparable to glass fiber composite and are being used as construction material. Kenaf fiber composites possess excellent tensile, flexural and impact strength. Kenaf fiber is being used as ropes, yarns and fabrics due to its low weight [2].

Researchers worked on successful fabrication of kenaf-PP composite with compression moulding. From Comparison of flexural and

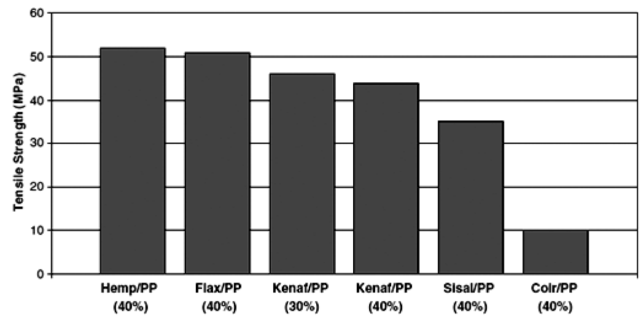


**Figure 4: Comparison of tensile strength of kenaf/PP-MAPP composite to other natural fiber composites[5].**

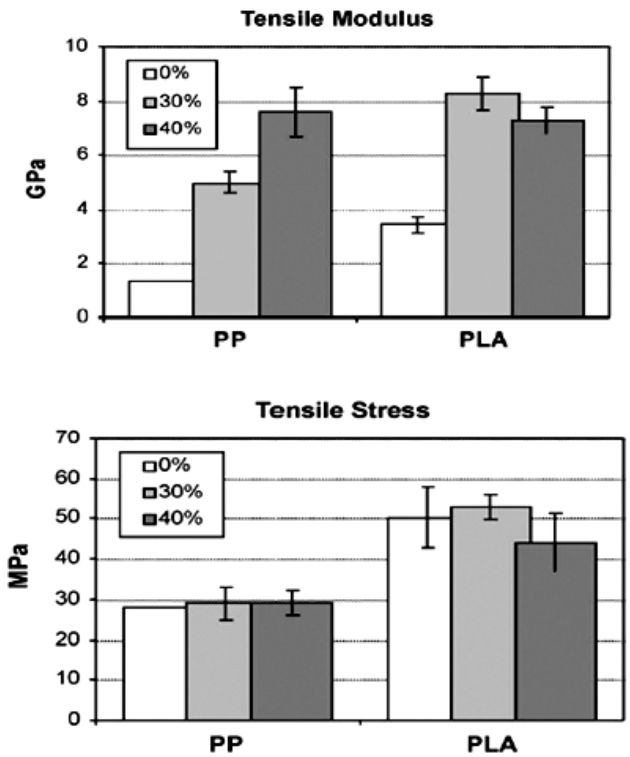


**Figure 5: Tensile stress and tensile modulus of PLA/flax composite compared with PP/flax[6].**

tensile strength of Kenaf, sisal and coir reinforced in PP matrix, it was concluded that Kenaf-PP composite is superior of all. It was also concluded that most optimal process to make this composite was compression moulding process with micro fine PP powder and chopped kenaf fibers. The kenaf-PP composite showed higher modulus/cost and higher specific modulus than sisal, coir and even E-glass[5].

Because of its biodegradability, researchers have also worked on PLA to use it as a matrix material in composites. The composite is prepared by compression moulding process with 30% and

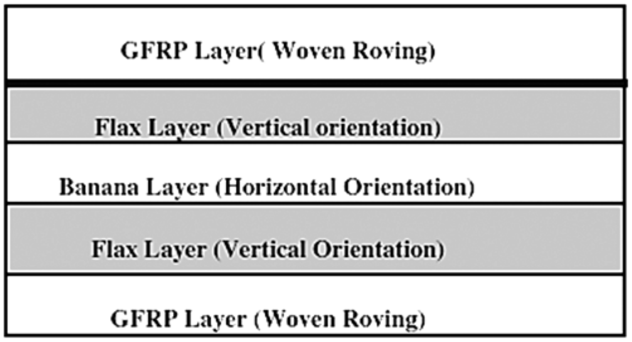


**Figure 6: Schematic representation of Hybrid Composite[7].**

40% flax fiber content by wt. %. It was found out that the strength of PLA/flax composite was 50% higher than PP/flax composite. The addition of fiber also increases the stiffness of PLA from 3.4 to 8.4 GPa. Triacetin was used as a plasticizer, its effect was negative on mechanical properties of composite. The processing of PLA was quite similar to PP composite. Interfacial adhesion of fiber and PLA was poor and need to be increased for better mechanical properties[6].Sandwich type composite structure is formed by two fibers combination of banana and flax in epoxy matrix using hand lay-up technique. One layer of banana fibers is sandwiched in two layers of flax fiber. In second arrangement Sandwiched layer of banana and flax with different orientation are laminated by one layer of glass fiber reinforced plastic (GFRP) for improving mechanical properties and better surface finish. Hybrid composite thus prepared has better impact properties, shear strength and flame retardancy than banana-epoxy composite and flax-epoxy composite. But the ultimate tensile strength and elongation is lesser [7].

Fiber type, textile architecture, inter-phase properties, fiber properties and content affect the fatigue behavior of Jute, flax (yarn and woven) reinforced with epoxy, polyester and polypropylene composite. Fine structure and surface morphology brings a significant difference between unidirectional hemp and jute epoxy composite in damping characteristics. Damage initiates at lower loads for woven reinforcement and less adhesion at the interface propagates it rapidly. Damage in composite can be reduced by increasing friction between fiber and matrix[8].The effect of fiber configuration on mechanical properties of a flax and tannin based composite was examined. In compression moulding of the composite non-woven and woven fibers were reinforced at different lay-up angles (UD, [0°, 90°] and [0°, 45°, 90°, -45°]). By characterization of samples from quasi-static tensile properties, dynamic mechanical properties and low-energy impact performance, it was investigated that UD fabric reinforcement composite performs better in tensile strength (up to 140 MPa) and modulus (9.6 MPa) than other configuration of fibers. The composite with [0°, 45°, 90°, -45°] fiber orientation was best in impact energy absorption. Glass transition temperature was around 60°C for all type of samples. From SEM analysis of the fracture surface it was concluded that failure mechanism of the tensile fracture were fiber pull-out, brittle tannin failure and fiber breakage[9].Date palm fiber can be reinforced with recycled polymer ternary blends like recycled low density polyethylene (RLDPE), recycled high density polyethylene (RHDPE) and recycled polypropylene (RPP) using injection moulding. Compatibility ofdate fiber with matrix materials can be enhanced using maleic anhydride (MA) as compatabilizer. Thermal stability, resistance to acids/alkalis, hardness, surface finish, flow-ability, tensile strength and tensile modulus increased with 1% addition of MA in the composite as compared to pure blend matrix [10].

Maleic Anhydride grafted Polypropylene (MAPP) can be used as a coupling agent in natural fiber/polypropylene composite to improve the adhesion between fiber and matrix. Work is done to finding out the optimum amount of MAPP. Natural fibers flax, hemp and sisal can be used as reinforcement in polypropylene matrix to make the composite. Stiffness, tensile and impact strength of composite was highest with 6.67% of

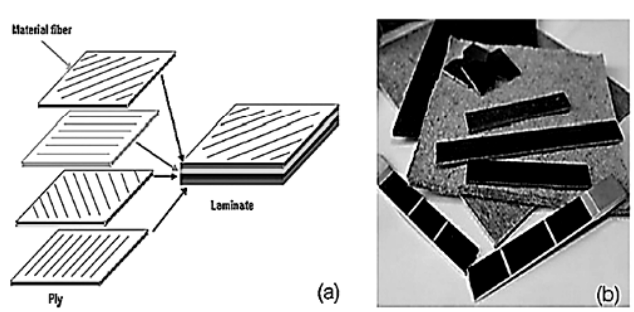


**Figure 7: (a) The vary of lay-up angles in the laminate; (b) resulted bio-composites [9].**

MAPP addition [11]. Additives like Polystyrene glycol, Polystyrene thioglycol, chlorinated aromatic polynuclear hydrocarbons, esters of saturated and unsaturated abietic acid, abietyl alcohols, esters of abietyl alcohols increases the stiffness and elasticity of bisphenol polycarbonate [12]. Properties of polypropylene (PP) improve by addition of various light stabilizers, antioxidants, nucleating agents etc. NORYL PPX* is an alloy of mPPE (modified polyphenylene ether resin) and PP released by GE plastics in 2001. NYROL PPX* possess properties ready-to-mould, better stiffness, more impact resistance, dimensional stability and temperature resistance makes it better than traditional polypropylene. But due to its high melting temperature (260-290 °C) this alloy can't be used as a matrix in NFPC[13]. Different surface treatments can be performed on natural fibers to increase compatibility with matrix material. Natural fibers are hydrophilic in nature and provide poor dimensional stability. Various types of chemical treatments on natural fibers using alkali, silane, benzoylation, acrylonitrile grafting, accetylation, melted coupling agent, permanganate peroxide, stearic acid, sodium chlorate, latty acid derivate, fungal etc reduce hydrophilic nature of the fiber and improve adhesion between fiber and matrix. Hydrophilic and hydroxyl groups can also be removed by chemical modification of fiber [4].Alkali treatment improves strength and modulus of the fiber. MAH-PP (maleic anhydride-polypropylene) coupling agent improves bonding of fiber and polypropylene matrix. Silane treatment can be carried out with polyester matrix to improve adhesion between fiber and matrix [4]. Interfacial strength and adhesion of natural filler in polymer matrix is an important issue. Surface energy forces between fiber and matrix often dominates the adhesion because in molten form polymer matrix cannot make any covalent bond at the interface. Alkali treatment of the fiber increases polarity resulting in improved strength. MAPP does not improve

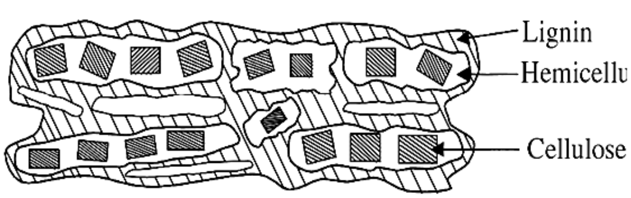


**Figure 8: Structural organization of the three major constituents in the fiber cell wall [4].**

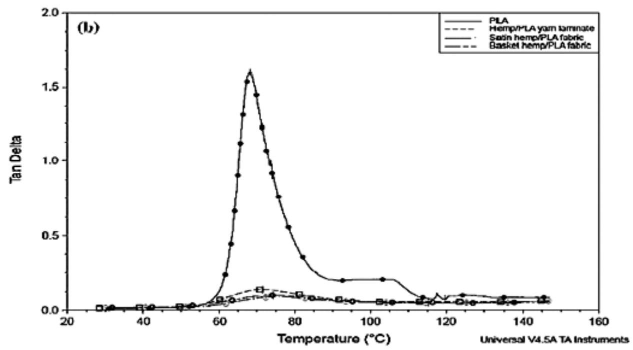


**Figure 9: DMTA analysis of thermoplastic PLA reinforced with of hemp fibre. Temperature vstanδ curves [15].**

physical adhesion with coir fillers but interface strength increase strongly because anhydride groups become active at processing temperature. Interface strength of coir/PVDF is superior than coir/PP composites [14].Pre-stressed flax fiber can also be used as filler material in polyester resin matrix. In this work the pre-tensioning of the fiber is studied. Pre-stressing can be done by two methods; pre-stressing of fiber before use and tensioning of fiber during curing process. Pre-stressing increases fiber packing density due to fiber straightening and decreased fiber obliquity. Pre-stressing of fiber reduces week spots thus dynamic effect on adjacent fiber due to weak fiber failure in composite is reduced. Strain induced in fiber during pre-stressing counters effect of thermal stresses produce during curing process. Slipping tendency of slack fibers on loading gets arrested due to pre-stressing of yarn. Fibers attain same length in final sample without any slackness ensuring uniform load bearing [3]. Weave structure of the hemp fiber in PLA (polylactic) matrix composite prepared by injection moulding affects mechanical properties and moisture absorption. Unidirectional hemp/PLA composite prepared using satin-weave patterns gives higher strength, toughness and strength due to least void content but shows poor damping characteristics (tanδ)[15].

From the Study of the effect of temperature, pressure, fiber, number of piles and matrix on the tensile strength of PLA matrix with jute, flax and cotton fiber as reinforcement, optimized manufacturing process was investigated. It was found out that with preheating of material from 2 min and 3 min under pressure a tensile strength more than 100 MPa was obtained. Higher temperatures may lead to low strength due to overheating of fiber and low temperature resulted in non-uniform melting of matrix in higher number of piles. The pressure variation from 8-3 MPa did not show any remarkable effect on tensile strength [16]. A regression technique was generated to predict laminate properties over a range of processing conditions by Taguchi Method with 5 compression moulding processing variables at 4 different levels. Samples were prepared of Glass fiber-PP comingled fabrics. It was concluded that void content decrease and stiffness increase with increase in preheat temperature, consolidation pressure and consolidation time. It was also observed that the micro and macro mechanical properties of the material were most affected by the preheat temperature of the fabric. Higher preheat temperature resulted in lower down the viscosity of PP which leads to better impregnation of the glass fiber. It was also seen that the metal tool of compression moulding machine increase cooling rate and reduce consolidation time [17].

**Table 1**
**Optimized Processing Conditions for Compression Moulding of Commingled Glass and Polypropylene Fabrics [17].**

| Tool Type | Medium density fiber board |
|---|---|
| Tool Temperature | 60 °C |
| Commingled fabric preheat temperature | 220°C |
| Moulding Pressure | 23 bar |
| Time at pressure | 45s |

## 3. CONCLUSIONS

From the above study it is concluded that the NFPC are the possible alternative for Man-made composites. Better interfacial properties, flame retardency and biodegradability of composite can be achieved by adding some additives or by some chemical treatments of natural fibers. MA treatment of fibers gives better interfacial adhesion in fiber and matrix. Orientation of fiber, lay-up angle, percentage of reinforcement, pretreatment of fibers etc. is the factors which govern the properties of composite.

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