

## **POTENTIALS FOR JUTE BASED COMPOSITES**

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It is a great honor to attend this 'Jute India' conference. and have the opportunity to present some ideas on composite materials based on jute. There is a greater awareness of the need for materials with an expanding population and jute-based composites provide an opportunity to fill this growing need for materials within a cost effective and acceptable environmental framework.

### **TEXTILE JUTE AND COMPOSITE POTENTIALS**

We have used jute fiber for so long in low value products, such as gunny bags, twine, and carpet backing, that we tend to consider jute as a low quality resource. We have also limited our thinking that the major use for jute, if not the only use, is for textile applications.

We have not accepted the vast potential for the use of jute in fiber-based composites. Part of this may be due to the idea that we have also accepted, or at least, learned to live with, jute-fiber limitations, such as rotting, swelling, and burning. Because of these limitations, we have not been able to accept the idea of producing long lasting, structural composite materials based on jute fiber.

Our history using jute in textile applications has limited our expectations of performance, which, ultimately, limits our ability to accept new concepts for improved jute-based composite materials. This is interesting as we have accepted completely new materials such as metal alloys, ceramics, and plastics that have limitations in their performance but we tend to overlook any deficiencies they may have because our expectations of these materials are higher than those we have for jute-based composites. Maybe it is because we think we know everything there is know about jute because it is a very old familiar fiber used by common people for low cost markets. We have limited our expectations of jute-based composites to a time long gone while years of advances in chemistry and materials science research have been taking place.

Jute fiber is not a low value resource with poor properties and it can be used in a great many value added products. Increased utilisation of jute in diversified, value added markets provides a great potential to improve rural India, expand exports, and add many new products into the Indian economy.

One of the problems with advances in jute technology is that most of us have been educated in what might be called traditional agro-science dogma and in many ways, we are locked into a mental framework tied to past technologies. We traditionally think of agro-based composites as solid, i.e. wood. We know solid, we trust solid, we understand solid. There has been a trend away from solid wood for many traditional applications toward smaller member composites. These new products started with glue laminated lumber, to plywood, to

flakeboard, to particleboard, and, finally, to fiberboard. At the fiber level, most defects in the resource have been removed. New fiber-based products introduce new concepts to be learned and understood such as adhesion, adhesives, interfaces, interphases, stress transfer, compatibilization, and the new composites require new performance standards and codes.

Using jute fiber for composites has many advantages. Jute is renewable versatile non-abrasive, porous, hydroscopic, viscoelastic, biodegradable, combustible, compostible, and reactive. The fiber has a high aspect ratio, high strength to weight ratio, is low in energy conversion, and has good insulation properties. Some might consider part of these properties as disadvantages, such as biodegradable and combustible, but these features provide a means of predictable and programmable disposal not easily achieved with other resources.

Even if we accept the possible use of jute for fiber-based composites, we may make another mistake in our thinking. That is, we want to use jute as a substitute for something else. In the composite area, we want to substitute jute for wood. For some applications, this makes a lot of sense especially with the Indian government ban on the use of wood for many applications. But, for many potential applications, it limits the possibilities for jute. Wood fiber comes in two lengths: short and shorter. So wood fiber is limited to short fiber applications. The long jute fiber bundles can be used to make fibre mats which can be used for geotextiles and can be formed into complex structural and non-structural products with the addition of an adhesive. The low density core of jute can be used for insulation (sound and thermal). So, you can take advantage of each fraction of the jute plant to form composites that are not a substitute for another resource, but the best resource for the job in itself.

It is also possible to use the whole jute plant for fiberboard. By doing this, the retting process is avoided. This would allow the farmer to sell his jute crop directly to a board processing center saving time and allowing them to put in another crop in the same year. This would provide the jute farmer with more options for his crop selection.

Another concern with using jute for fiber-based composites, is that the jute process system now in place in India is still based on the jute mill which is still processing jute for textile applications. Jute used for composites could be processed in a simpler system that is more cost effective. The present jute mill can be used for long fiber preparation and fibre mat formation but very little else is needed in the present jute mill infrastructure for the production of fiber-based composites.

The scheme shown below gives possible processing pathways that lead to the composite products that can come from each fraction of the jute plant. The entire plant (leaves, stock, pith, roots) can be used directly to produce structural and non-structural composites and can be used in combination with thermoplastics to produce pellets that can be extruded into a wide variety of products. By using the entire plant, processes such as retting, fiber separation, fraction purification, etc. can be eliminated which increases the total yield of plant material and reduces the costs associated with fraction isolation. The plant can be fractionated into fiber types and each type utilized for different composites. By utilising the by-product from the long fiber isolation process, for example, the overall cost of long fiber utilization is reduced.

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WHOLE PLANT -----> LONG FIBER -----> MATS

[Fiberize]	<b>PITH</b>	Filament	Filters,
		wrapping,	Geotextiles,
		Inorganic	Packaging,
		bonded	Molded
			structural
Structural and	Sorbents,		composites,
Non-structural	Packing,		Resin transfer
composites,	Light weight composites,		molding
Combinations	Insulation,		
with other	Filters,		
resources	Core materials		

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The pith can be used for sorbents, filters, insulation, and cores of laminated products such as doors, windows, and wall coverings. The long bast fiber can be used in filament wrapping type technologies in place of fiber glass and used in inorganic bonded (cement) composites. The long fiber can also be made into fiber mats using carding, needling or thermobonding technologies. The mats can be used for geotextiles, filters, packaging, resin transfer molding, and molded structural applications. Jute cloth or paper overlays can also be used as a face covering over low or medium density flat sheets for wall covering, doors, room dividers, and insulation materials.

This is just a partial list of the many possibilities in which jute fiber can be used in composite materials. We are only restricted in the possibilities by our training, tradition, and imagination.

It should also be remembered that jute is only one natural renewable, sustainable fiber grown in India. There are many other agricultural resources that can be used in combination with jute to produce cost effective composites.

### PROPERTY ENHANCED COMPOSITES

A single jute fiber is a three dimensional composite composed mainly of cellulose, hemicelluloses, and lignin with minor amounts of protein, extractives and inorganics. These fibers were designed, after millions of years of evolution, to perform, in nature, in a wet environment. Nature is programmed to recycle jute, in a timely way, back to basic building blocks of carbon dioxide, and water through biological, thermal, aqueous, photochemical, chemical, and mechanical degradations. In order to expand the use of jute fiber-based composites in adverse environments, it is necessary to interfere with nature's recycling chemistry.

One of the most studied chemistries to interfere with nature's recycling chemistry and improve performance properties of jute fiber based composites involve reactions with acetic anhydride (acetylation). Chemical modifications of this type react with accessible hydroxyl groups on the cell wall polymers. These are the same hydroxyl groups involved in the natural degradation chemistries. The addition of a simple acetate group on the natural fiber changes both rate and



**Acetylation of jute fiber using acetic anhydride.**

equilibrium properties. Table below shows a summary of some of the properties changed through this simple chemistry. Moisture sorption is greatly reduced as evidenced by a reduced

Equilibrium moisture content (EMC), thickness swelling (TS), biological resistance modulus of rupture (MOR), modulus of elasticity (MOE), and tensile strength (TnS) parallel to the board surface of fiberboards made from control (J) and acetylated jute (AJ) fiber (8% phenolic resin).

	Weight Percent Gain %	EMC* %	TS* %	Weight Loss After 12 Weeks		MOR MPa	MOE Gpa	TnS MPa
				Brown-rot Fungus %	White-rot Fungus %			
J	0	18.2	19.6	65	8	40.1	4.5	23.0
AJ	19.6	7.2	2.1	<2	<2	42.9	4.7	24.7

\* at 27 °C, 90% RH

equilibrium moisture content in the cell wall. Cell wall swelling has been reduced by a factor of almost 10 and attack by both brown- and white-rot fungi has been greatly reduced. Mechanical properties are not changed. Acetylated fiber has also been shown to be more resistant to attack by termites, bacteria and ultraviolet radiation. Acetylated fiber has similar thermal properties as compared to untreated fiber. Many other chemistries have been used with similar results, however, acetylation is the simplest and safest as compared to other chemistries such as isocyanates; epoxies, etc.

Limitation in performance of jute-based fiber composites can be greatly improved through chemical modification techniques. While we apply these chemistries everyday to change the properties of synthetics (textiles, carpeting, etc), we do not apply these same technologies to jute-based resources. We have only begun to explore property enhancement chemistries of jute-fiber based composites.

Property enhanced jute-based composites would be produced for performance driven markets and not for the traditional cost driven markets in which jute competes today. This is also a change in thinking that must take place before jute-based composite products.

## **CONCLUSIONS**

- (1) There are several manufacturers in India that are now producing jute-based composites, however, the vast potential has not been realized. Markets for composites based on jute are potentially larger than all past markets for jute in textile applications.
- (2) Limits in the development of fiber-based composites from jute are mainly due to a lack of understanding of the resource and now its characteristics can be used to our advantage.
- (3) There is a need for research on properties and performance of each type of proposed composite product. Research, however, can go on forever but, in most cases, there is enough data to convince industry to start using a new resource over the one they presently use. Research can just push so far to get a new product into the market. At some point the market must pull the technology into use. There are many examples where there has been a strong research push but no market pull and so the technology remains in the research arena.
- (4) There needs to be a strong push to develop codes and specification of each desired composite product. In some local Indian markets there may be no or zero codes. For those markets it is not necessary to develop or follow existing codes. Certainly for international markets, there will be a need to follow codes and specifications for the intended country. Without this, there is no hope of entering that country's markets with a new material.
- (5) As a collective industry, the agro-based resource community must do a very careful life cycle assessment to prove our assumed position of creating “environmentally friendly” products. Until hard data is collected, analyzed, and presented, the agro-based industry can not prove, for example, that it uses less water, less energy, causes less pollution, and has a plan for recycling, as compared to using other resources.
- (6) The entire Indian agro-based industry (jute, cotton, food crops, flax, wood, etc) should develop a strategy for an Indian and, perhaps, a global biodiversity and sustainable fiber supply. Projection of global fiber needs exceed the projected timber supply, world wide, so there is an opportunity for agro - based fibers to fill this gap. This would include fibers used for composites as well as other applications such as pulp and paper.
- (7) High performance adhesives along with fiber modification can be used to manufacture structural jute-fiber based composite materials with uniform densities, durable in adverse environments, and high strength.
- (8) Structural products having complex shapes can be produced using flexibly jute fiber mats. This type of composite can make a major impact on housing construction in India.

(9) Many composite products that have been discussed in this paper can be made from natural or modified jute fiber. Many other products can be produced which have natural or modified jute fibers as a component in the composite. These include combinations with thermosets, thermoplastics, glass, metals, synthetics, other natural fibers, and inorganic.

(10) There should be a big effort on marketing jute-based composites. Information in the public sector on jute - based composites ranges from no information to misinformation. very little information exists on properties, performance, and potential applications for jute-based composites and until consistent, reliable, and trustworthy information gets into the hands of consumers, jute-based composites will remain in small local markets.

Finally, jute can play a major future economic role in India through the production of fiber-based composite materials. We have two choices, we can put our collective hands in our pockets and lament the passing of the “good old days” when the jute industry was strong or we can put our collective minds and resources into revitalizing and diversifying jute into a bright new future in composites.



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**INDIAN JUTE -  
PERSPECTIVES**