
Bio-Composites
By: Kavita H. Sundakar

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1. ABSTRACT

In today's world, there is an increasing demand towards component materials that are durable, lightweight, and reliable and with mechanical properties that are significantly better than those of the traditional materials. It is preferable if these materials are eco-friendly and bio-degradable at the same time. Biocomposite materials have shown signs of satisfying most of the above conditions. We shall focus primarily on the recent trends and developments in Biocomposites as applied to the medical and building industry, in this paper. The advantage of using biocomposite material is that it is eco-friendly. The concept of a green kitchen, benefits of using biocomposite material such as wood cement fibers, cement fibers and sisal fibers have been discussed. Their applications have also been highlighted.

2. INTRODUCTION

The term 'Biocomposites' refers to those composites that can be employed in bioengineering. Composites are those materials that contain two or more distinct constituent phases, on a scale larger than the atomic. The constituents of the composite retain their identities in the composite. In other words, they do not dissolve or otherwise merge completely into each other although they act in concert. Properties such as the elastic modulus can be significantly different from those of the constituents alone, in composites. But they are considerably altered by the constituent structures and contents. Composites are anisotropic in nature from a structural point of view. Biocomposites are composite materials formed by a matrix (resin) and a reinforcement of natural fibres (usually derived from plants or cellulose). Biofibers are one of the major components of Biocomposites. It is the fibrous material derived from shrub, tree or plant sources. Biocomposites are the combination of natural fibers (biofibers) such as wood fibers (hardwood and softwood) or non -wood fibers (e.g., wheat, jute, kenaf, hemp) with polymer matrices from both of the renewable and nonrenewable resources. In addition to the strengthening properties of the matrix that was used, biocomposites often mimic the structures of the living materials involved in the process. But still it provides biocompatibility. The structure and service environment are important factors in deciding the degree of biodegradability in bio -based polymers. Natural/Biofiber composites are emerging as a viable alternative to glass fiber composites. It is becoming one of the fastest growing additives for thermoplastics. The integration of "soft" biological and organic molecular assemblies with "hard" inorganic nano-architectures is of special interest because of the opportunity to combine normally disparate chemical and physical properties within a single system. Further, research into biological-inorganic interfaces focuses on the synthesis, design and characterization of novel amalgams that fuse biological and inorganic materials.

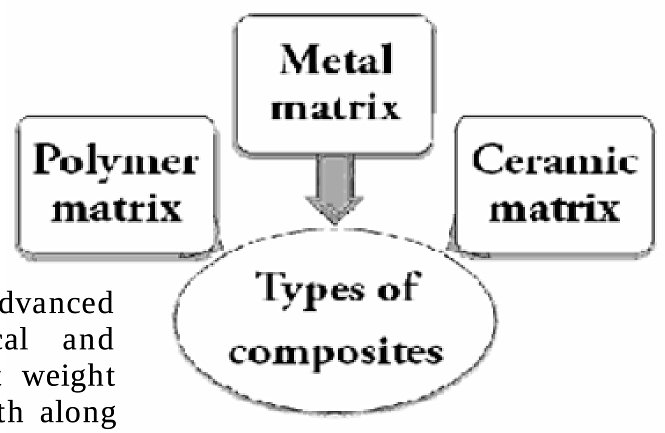
3. TEXTILE COMPOSITES

Two inherently different materials are mixed to form a new material called composite material which is different to both but better in properties. Also, "composites" are to be materials in which a homogeneous "matrix" component is "reinforced" by a stronger and stiffer constituent that is usually fibrous, but may have a particulate or other shape. The two constituents of the composites are called matrix and resin.

1. **Matrix**
   It is the main constituent of composites materials mainly responsible for its mechanical properties. Its percentage in the composite may be up to 70% by volume.
2. **Adhesive /Resin**
   Normally it is a synthetic polymer with an objective to bind the matrix elements.

Types of composites:

Polymer Matrix:
Polymer matrix composites contain continuous fibres, short fibres or particles in a polymer matrix. Broadly, the cost of the reinforcement is greatest for continuous fibres, and least for particles. Volume fraction of reinforcement typically 30-60%. Advanced composites exhibit desirable physical and chemical properties that include light weight coupled with high stiffness and strength along the direction of the reinforcing fiber, temperature, dimensional stability, chemical resistance, relatively easy processing and flex performance.



Types of composites

Metal matrix:
The materials are reinforced into metal matrix to produce composites. These are having stiffness more but heavier than polymer matrix composites.

Ceramic Matrix:
The ceramic is used for reinforcement. Need for Biocomposites:
As we know textile composites are generally made up by using synthetic materials so these are non-biodegradable and the sources are non renewable. Due to some environmental issues such non-biodegradable materials are inviting pollution and hazardous to human beings as well as flora and fauna of the ecosystem.

To avoid all such effects people applying "Go Green" theme everywhere in 21st century. So here is the better option i.e. Biocomposites.

4. WHAT DOES BIOCOMPOSITES MEAN?

Biocomposites are composite materials formed by a matrix (resin) and a reinforcement of natural fibres (usually derived from plants or cellulose). Biofibers are one of the major components of Biocomposites. It is the fibrous material derived from shrub, tree or plant sources. Biocomposites are the combination of natural fibers (biofibers) such as wood fibers (hardwood and softwood) or non -wood fibers (e.g., wheat, jute, kenaf, hemp) with polymer matrices from both of the renewable and nonrenewable resources.

Classification of Biocomposites:

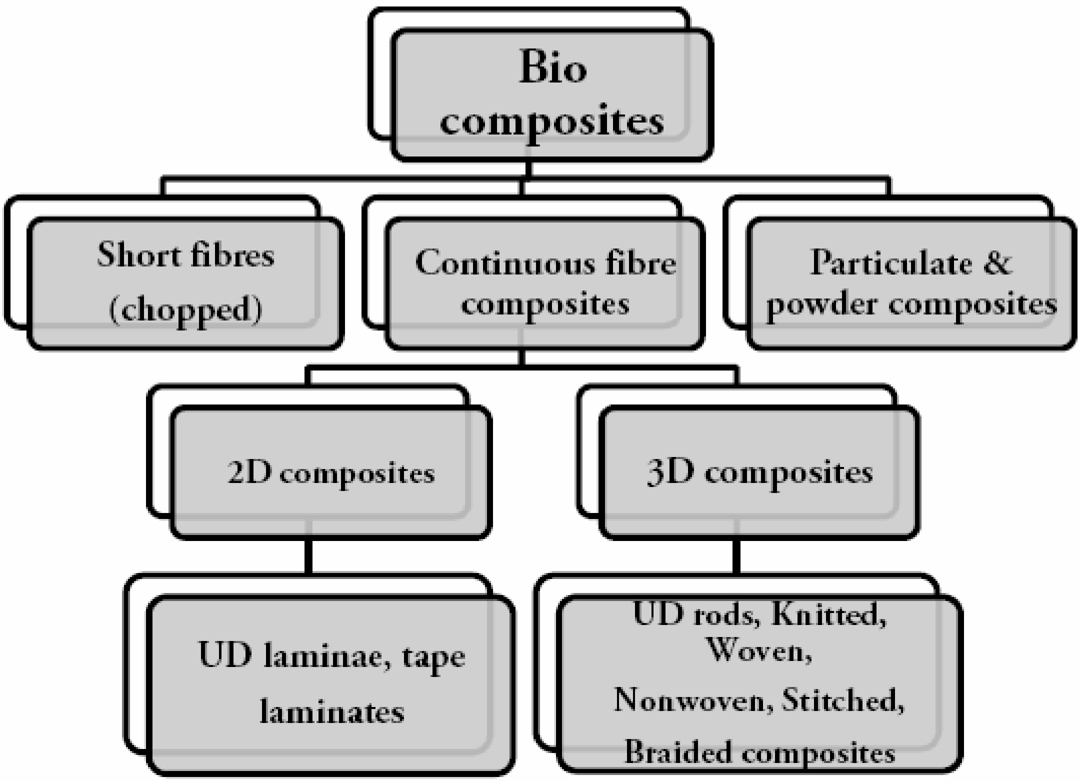


Figure: Classification of biocomposites

5. MATERIALS USED

- Non degradable petroleum products
- Biopolymers
- Biofibers
- Plant fibres such as cotton, flax, hemp, kenaf, sisal, soya bean
- Fibres from recycled wood or waste paper or viscose derived from regenerated cellulose
- By-products from food crops are used.

1. Wood Residue
2. Oil Palm Tree
3. Kenaf
4. Rice Straw

Figure: Natural materials for biocomposite

6. MANUFACTURING TECHNIQUES

Composites are hybrid materials made of a polymer resin reinforced by fibres. It combines the high mechanical and physical performance of the fibres and the physical properties, appearance and bonding of polymers. Making of composites generally makes use of two materials which are as follow:

1. Fibres
2. Resin material

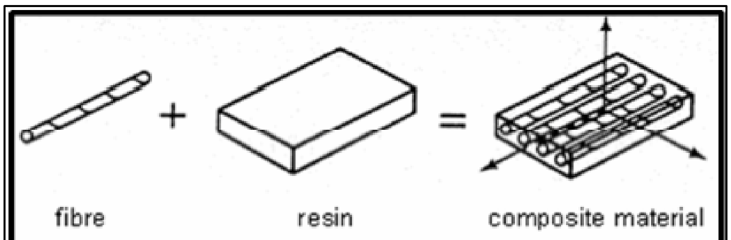
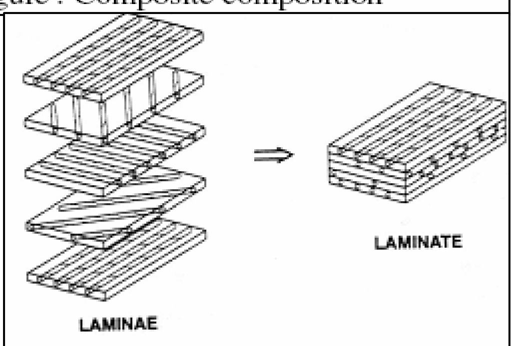


Figure : Composite composition

The short and discontinuous fibre composites are responsible for the biggest share of successful applications, whether measured by number of parts or quantity of material used. The most important part in composites is that they are tailor made products i.e. their physical and mechanical properties can be moulded according to the need of user. Therefore different layers of fibres are sandwiched together to obtain the composite material. As shown in the figure below we can observe that how fibres placed in different directions on combining together overcome the



Tailored Composites

strength problems which they faced in individual stage.

The composites make use of number of techniques for their manufacturing but the most commonly used manufacturing processes are as follow:

- Hand laminating
- Resin injection technique
- Hot pressure method
- Filament winding
- Pultrusion

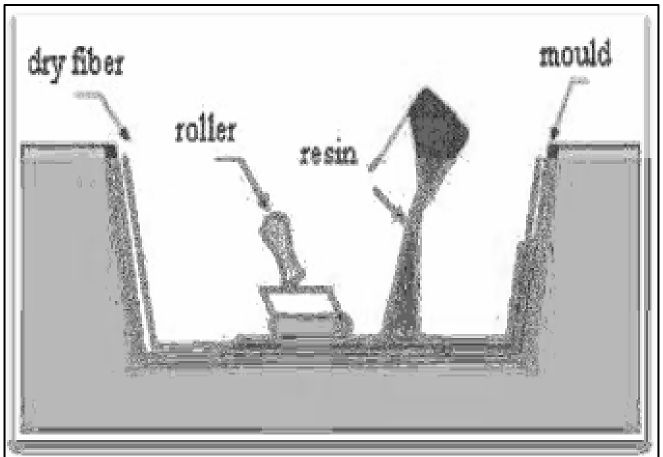


Figure : Wet Hand lay up

☞ Hand Laminating:

Chiefly used for polyester resin and practiced where very large article is to be made.

Sequence of operation:

1. Chopped fiber/ sliver/woven fabric and resin are sprayed on to the mould with a special gun or by hand.
2. Trim and allow curing
3. After curing article is released from the mould.

Advantages:

- No size limitation
- Adaptable production method since metals or extra fabric can be added.
- Does not require power to mould and low pressure process
- Curing can be done at room temperature and it varies from room temperature to 80°c.
- It is suitable for small production run.

☞ Resin Injection Technique:

Sequence of operation:

1. Reinforcing jute, in fiber/fabric/non-woven form is laid on the mould.
2. A matching mould half is mated to the other half containing jute and clamped tightly.
3. A pressurized resin system mixed with catalyst is punched from one or more tanks into the mould.
4. Resin and fibre stays in the mould for efficient curing. After this the solid part is removed.

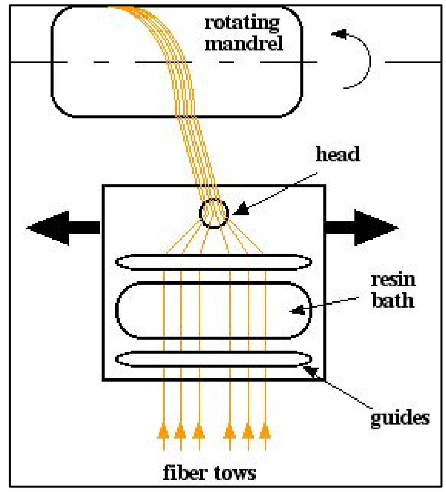
Advantage: Rapid manufacturing of large complex.

☞ Hot Pressure Method:

Operation: Composite pre forms inserted in mould & cured using heat & pressure.

Advantage: Manufactures complex products

☞ Filament Winding Process:



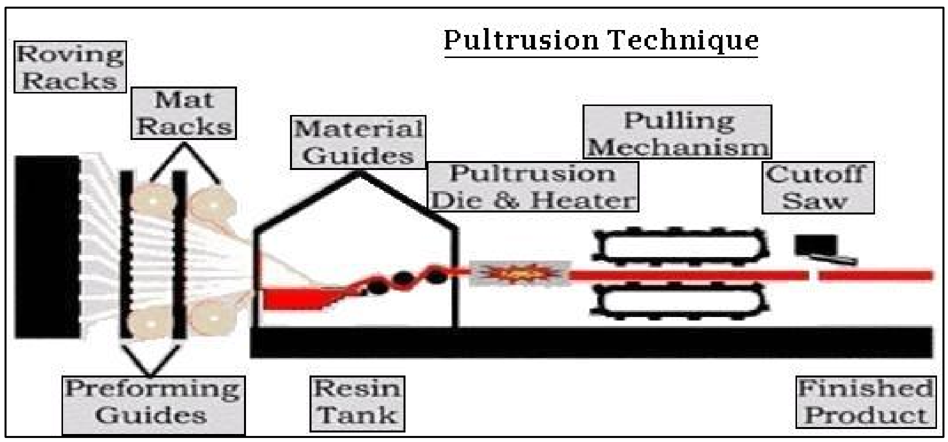
Operation:

- Filament winding is a high volume, automated process used to manufacture products with cylindrical shapes such as pipes, shafts, pressure vessels, tanks and tubing.
- A winding machine pulls dry fiberglass through a resin bath and around a mandrel. All fibers must be wound using the same tension, to ensure part performance.

Advantages:

1. High strength
2. Larger structures

☞ Pultrusion Technique:



Operation:

- ∈ Fibers are pulled from a creel through a resin bath and then on through a heated die.
- ∈ The die controls the resin content, completes the impregnation of the fibre and cures the material into its final shape as it passes through the die.
- ∈ This cured profile is then automatically cut to length.
- ∈ Pultrusion typically uses fiberglass and thermoset resins such as polyester, phenolic, epoxy and vinyl ester.

Advantage: It is cost-effective in high volume production runs of constant cross section parts. Pultrusion is a continuous process.

☞ Concept of "GO GREEN":

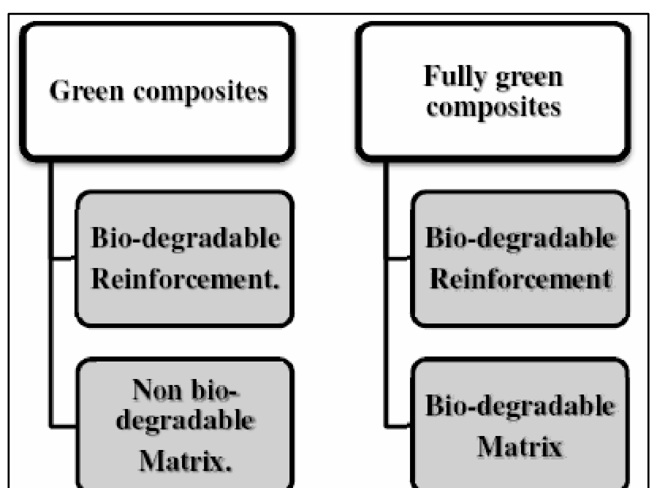


Figure : Green & Fully green Composites

Green Composites

Increased environmental awareness and societal needs serve as a catalyst for developing new eco-friendly materials like green composites. Composites with natural fibres have the potential to be attractive alternative to synthetic fibre composites. Today fibre composites are replacing traditional petroleum based products such as resins in thermoset plastics. They are non-biodegradable and toxic.

To create natural composite materials, green composites combine plant fibres with natural oil resins like soybean-oil. In the case of "Green" composites, natural fibres derived from flax, bamboo or hemp are being added to biodegradable resins in order to reinforce polymer matrix materials and improve the mechanical properties of resulting composites. The resin and fibre in the green composites are biodegradable, when they dumped, decomposed by microorganisms. They are converted into form of H2O and CO_2. These Two are absorbed into the plant system. The two main components of green composites are as follow:

1. Natural fibres
2. Biodegradable Resins

Types & Properties:

Environment-friendly "Green" composites were fabricated from cellulose fibres and a starch-based, dispersion-type biodegradable resin. The mixture of the dispersion-type biodegradable resin and cellulose fibres were blended well by using a home-use mixer/stirrer, and then dried in a vaccum or in air. Composites were prepared by conventional hot pressing at a constant temperature of 140°C and at pressures of 10 to 50 MPa their flexural strength as well as flexural modulus increased with increasing the moulding pressure.

The composites were from a starch based biodegradable polymer and Manila hemp fibres. The tensile strength of cross-ply composites increases with the fibre content until nearly 50% by weight. The tensile strength of "Green" composites is strongly dependent on fibre content.

7. APPLICATIONS OF BIOCOMPOSITES

Automobile

In recent years there has been a revival of interest in natural fibre such as sisal, kapok and jute for use in automobiles especially in composites. The idea is of using natural fibres as reinforcement in a thermoplastic matrix. Natural fibres such as flax and kenaf can easily compete with classical reinforcement (glass fibre) in term of mechanical properties. The natural fibres have several advantages such as low cost, low weight, good availability and ecological advantages. The approach of using plant fibres as reinforcing components goes along with the intention to reduce the green house effect by establishing a nearly closed carbon dioxide cycle. This is the reason that an individual European car makes use of 5 – 10 kgs of natural fibres in it.

Automotive interiors with the reinforcement of natural fibres are considered to be physiologically safer than glass fibre parts as no sharp edged fracture appears in case of crash. Further advantages results from their air conditioning effect and in particular high absorbency. With respect to industrial safety they don't cause allergic reactions or skin irritation. Finally a positive image and product marketing related to the utilization of renewable material should be taken in consideration.

Table: Scope of Bio composites In Automobile			
Application	**Fiber**	**Matrix**	**%fiber**
Door panels /inserts	Kenaf/hemp	Pp	50%
Rear parcel shelf	Flax/wood	Pp	50%
Seatbacks	Flax	Pp	50%
Spare tyre covers	Wood	Pp	85%
Other interior trim	Kenaf/flax	Pp	50%

Fluid Containers

Using cost effective filament winding equipment, reusable containers for transport and storage of liquids (water, beer, wine, fish-and soy-sauce) can be filament wound from spun natural fibres. The container becomes "foldable-when-empty", using natural rubber as resin. The contents remain cool due to the thermal properties of the natural fibres. The advantage over plastic or steel vessels is the reduction in transport and manufacturing costs, the environmental friendly design and the low weight.

Sisal Storage Container

Roofing Panels

Natural fibres and resin material can be pressed into laminates that can act as skins of so called sandwiches (layered panel consisting of skins and a core). Compared to corrugated iron roofing the natural fibre sandwich has improved thermal and acoustic insulating properties and doesn't cause zinc and rust pollution. The natural fibre sandwich is probably cheaper to manufacture, due to the use of local resources. The sandwich is more durable, in comparison with traditional vegetable roofing. Similar panels can also be used as tabletops, shelves and doors.

Coir Cement Roofing:
Coir fibres are soaked in mineral water and than mixed with dry cement in ratio 1:5. The sheet thus formed is held under pressure for 4-8 hours. These sheets generally show very good results.

Bamboo and Its Composites:

Bamboo is a fast growing material and therefore finds large applications. Bamboo exhibits excellent physical and mechanical properties.

Composites made of bamboo can be used for making sandwich structural panel. They provide thermal insulation and can fulfill a primary structural function. A

Bamboo Biocomposites

bit less insulating, but still very well suitable for wall and roof construction are sandwiches made of natural fibre composite skins and bamboo pillars as sandwich core. Due to insulation property bamboo fibre is far better than steel in performance.


Small Boat (Canoe)

Small Boats:

Small canoe-like boats can be manufactured with vacuum techniques. They are more durable than wooden, steel or bamboo boats. These boats withstand corrosion better than metal boats and the low weight makes them easy to handle, both ashore and in the water.

Bridges:

Using pultrusion technology, natural fibre construction profiles can be manufactured at any length, see figure 14. A very useful application of these profiles in combination with the panels described earlier is a simple pedestrian bridge, see figure 15. This bridge is easily transported to remote locations due to its lightweight and withstands tropical conditions better than metal bridges. A less complicated foundation is required, due to the low weight. Also window-or doorframes, scaffoldings and tubes can be made.


Pedestrian Bridge

8. ADVANTAGES AND DISADVANTAGES

Advantages of Bio composites over Traditional Composites

1. Reduced weight
2. Increased flexibility
3. Greater mold ability
4. Less expensive
5. Sound insulation
6. Renewable resource
7. Thermal recycling is possible where glass poses problems
8. No skin irritation and friendly processing

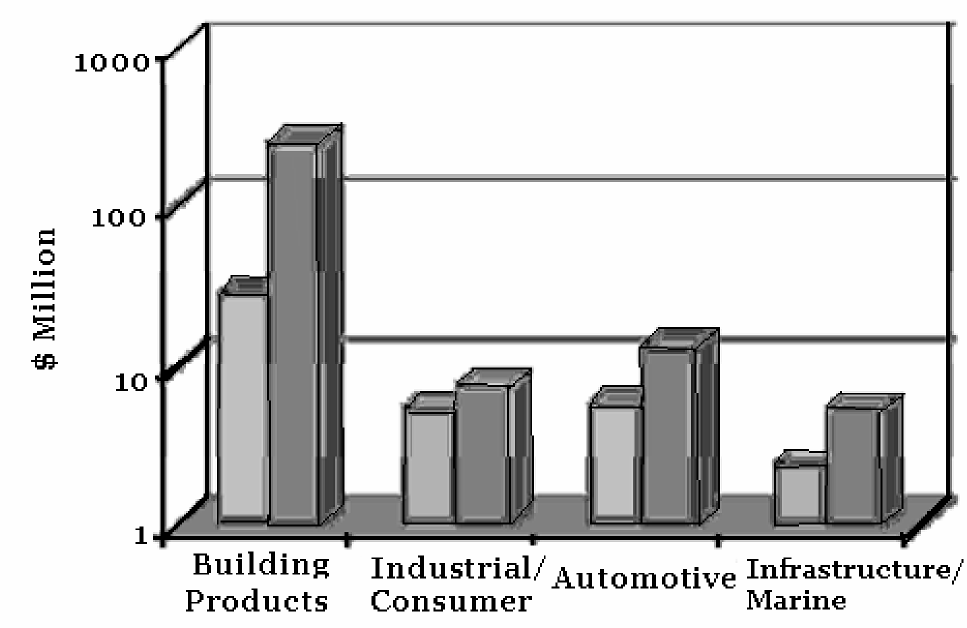
Disadvantages of Biocomposites

1. Lower strength properties, specially impact strength
2. Influence of unpredictable weather leading to variable quality.
3. Swelling of fibres caused by good moisture absorption.
4. Lower durability
5. Poor fire resistance
6. Irregular fibre lengths

9. FUTURE OF BIOCOMPOSITES

Eco-efficiency, green chemistry, sustainability and industrial ecology are guiding the development of the next generation of products, processes and materials.

Biodegradable plastics and bio-based polymer products based on annually renewable agriculture and biomass feedstock can form the basis for a portfolio of sustainable products. These products can compete and capture markets currently dominated by products based exclusively on petroleum feedstock. It is the only source available today that focuses on natural fibers, bio-based materials, biopolymers.



Growth Outlook for Biocomposites

10. CONCLUSION

Development of Biocomposites as an alternative to petroleum based materials is reducing carbon dioxide emission, generating more economical opportunities for the agriculture sector and addressing the dependence on imported oil. Biocomposites also offer opportunities for reduced energy consumption, sound absorption properties, environmental gains and insulation. In recent times, use of biocomposites in building materials offers advantages like lightweight, bio-renewable, more durable, environment friendly and affordable. On the other hand, they have some disadvantages as well such as photochemical degradation because of the UV radiations and moisture absorption. To address these issues there is some on going research. Furthermore, biocomposites offer opportunities for reduced energy consumption, sound absorption properties, environmental gains and insulation.

Industries Manufacturing Biocomposites all Over the World

- Ashland Specialty Chemicals.
- Baltix
- Environ Biocomposites, US Company.
- Flexform Technologies LLC, US Company.
- Phenix Biocomposites.

- Kineco group, Goa
- Greendiamz Biotech, Pvt ltd.
- Composite Technology Park, Bengaluru
- Indo-Uk Symposium on Biocomposites, Indian Institute of Science, Bangalore

References

1. *Review Of Recent Trends & Developments In Biocomposites,By Ramesh S Sharma Dr.V.P.Raghupathy Sai Sashankh Rao Shubhanga P*
2. *Bio-Composite Materials As Alternatives To Petroleum-Based Composites For Automotive Applications, Lawrence T. Drzal, A. K. Mohanty, M. Misra Composite Materials And Structures Center Michigan State University*
3. *Green-composites: manufacturing & applications,O L Shamugasundaram,Dept.of Textile Technology,KSR college of Technology,Tiruchingode, The Indian Textile Journal,Feb,12.*
4. *Www.Google.Com*
5. *Www.Fiber2fashion.Com*
6. *Biocomposites: A Futuristic Approach For Ecofriendly Textiles By: Dr. Arshia Hussain And Dr. Alka Goel*