

A NEW GENERATION OF COMPOSITE MATERIALS FROM AGRO-BASED FIBER

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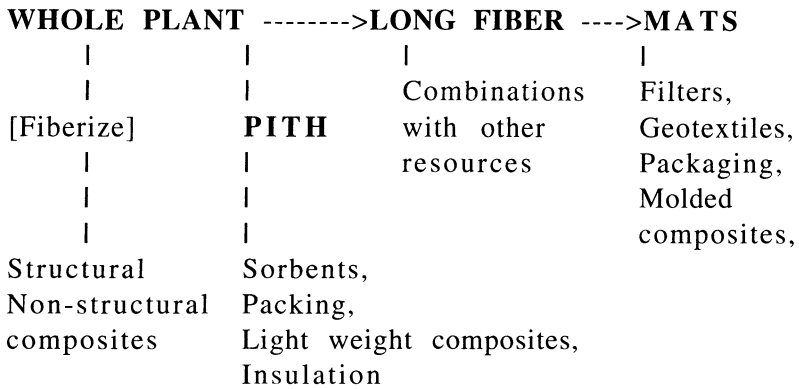
INTRODUCTION

Agro-based fibers are classified according to what part of the plant they come from. Five different fiber classifications will be used in this report: (1) bast or stem fibers, which are the fibrous bundles in the inner bark of the plant stem running the length of the stem; (2) leaf fibers, which run the length of leaves; (3) seed-hair fibers; (4) core, pith or stick fibers, which form the low density, spongy inner part of the stem of certain plants; and (5) all other plant fibers not included above. Examples of bast or stem fibers include jute, flax, hemp, kenaf, ramie, roselle, and urena. Leaf fibers include banana, sisal, henequen, abaca, pineapple, cantala, caroa, mauritius, and phormium. Seed-hair fibers include coir, cotton, kapok, and milk weed floss. Core fibers represent the center or pith fibers of such plants as kenaf and jute and can represent over 85 percent of the dry weight of these plants. The remaining fibers include roots, leaf segments, flower heads, seed hulls and short stem fiber.

While individual single fibers in all of these classes are quite short (except for flax, hemp, ramie, cotton, and kapok), fiber bundles can be quite long. For example, hemp, jute, and kenaf can have fiber bundles as long as 400 cm and abaca, mauritius, and phormium are about half this length. Considering all plant fiber types, there is a vast array of potential long and short fibers for composite production.

PLANT UTILIZATION FOR COMPOSITES

Scheme 1 shows possible processing pathways that lead to the composite products identified in this report that can come from each fraction of the plant. The entire plant (leaves, stock, pith, roots) can be used directly to produce structural and non-structural composites. 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. This also gives the farmer a different option in their crop utilization. That is, bringing in the entire plant to a central processing center and not having to get involved in plant processing.



Scheme 1 - Possible processing pathways from each plant fraction.

Another option is to separate the higher value long fiber from the other types of shorter fiber and use it in combination with other materials to make value added structural composites. When the long fiber is separated, the by-product is a large amount of short fiber and pith material that can be used for such products as sorbents, packing, light weight composites, and insulation. By utilizing the by-product from the long fiber isolation process, the overall cost of long fiber utilization is reduced.

The isolated long fiber can then be used to make mats which have value added applications in filters, geotextiles, packaging, molded composites, and structural and non-structural composites.

POTENTIAL COMPOSITES FROM AGRO-RESOURCES

For this report, a composite will be defined as any combination of two or more resources held together by some type of mastic or matrix. Composites can be classified in many ways: by their densities, by their uses, by their manufacturing methods, or other systems. For this report, they will be classified by their uses. Eight different use classes will be covered: (1) geotextiles, (2) filters, (3) sorbents, (4) structural composites, (5) non-structural composites, (6) molded products, (7) packaging, and (8) combinations with other materials Rowell 1993). There is some overlap between these areas. For example, once a fiber web has been made, it can be directly applied as a geotextile, filter, or sorbent, or can be further processed into a structural or non-structural composite, molded product, used in packaging, or combined with other resources. Within each composite made there are opportunities to improve the performance of that composite by improving the performance of the fiber going into the composite.

(1) Geotextiles

The long bast or leaf fibers can be formed into flexible fiber mats, which can be made by physical entanglement, nonwoven needling or thermoplastic fiber melt matrix technologies. The two most common types are carded and needle punched mats. In carding, the fibers are combed, mixed and physically entangled into a felted mat. These are usually of high density but can be made at almost any density. A needle punched mat is produced in a machine which passes a randomly formed machine made web through a needle board that produces a mat in which the fibers are mechanically entangled. The density of this type of mat can be controlled by the amount of fiber going through the needle board or by overlapping needled mats to give the desired density.

Numerous articles and technical papers have been written and several patents have been issued on both the manufacture and use of nonwoven fiber mats containing combinations of textile and lignocellulosic fibers or lignocellulosic fibers alone. This technology is particularly well-known in the consumer products industry. Medium- to high-density fiber mats can be used in several ways. One is for the use as a geotextile. Geotextiles derive their