MANUFACTURE AND CHARACTERIZATION OF PARTICLE BOARD USING ARECA HUSK

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ABSTRACT

The objective of this study was to develop an environment-friendly particleboard using tannin-based resin. Tannin-based resin was used in the surface layer of particleboard to replace urea-formaldehyde resins. In addition, we manufactured particleboard using epoxy resin to compare with. We successfully prepared tannin-based resin i.e. tannin phenol formaldehyde resin and made sure that the values of viscosity, gel time, PH were satisfied with the standard bio resins. Later two boards were manufactured by providing suitable environment and compressed under high pressure. The two boards prepared were subjected to various physical and mechanical tests like density, tensile strength, water absorption etc. The results of the tests conducted for both the boards were compared with the standard values and the result was satisfactory.

Key words: Tannin phenol formaldehyde (TPF), Areca husk, Epoxy, Low density board, Medium density board.

INTRODUCTION

PARTICLE BOARD

Particle board – also known as particleboard, low-density fibreboard (LDF), and chipboard – is an engineered wood product manufactured from wood chips, sawmill shavings, or even sawdust, and a synthetic resin or other suitable binder, which is pressed and extruded. Oriented strand board, also known as flakeboard, waferboard, or chipboard, is similar but uses machined wood flakes offering more strength. All of these are composite materials that belong to the spectrum of fibre board products.

CHARACTERISTICS

Particle board is cheaper, denser and more uniform than conventional wood and plywood and is substituted for them when cost is more important than strength and appearance. However, particleboard can be made more attractive by painting or the use of wood veneers onto surfaces that will be visible. Though it is denser than conventional wood, it is the lightest and weakest type of fibreboard, except for insulation board. Medium-density fibreboard and hardboard, also called high-density fibreboard, are stronger and denser than particleboard. Different grades of particleboard have different densities, with higher density connoting greater strength and greater resistance to failure of screw fasteners.

ADVANTAGES:

Low Cost

Ready-made furniture

Pre-laminated board

Light-weight

FIBRE BOARD

Fibre board (American spelling) or fibreboard (Commonwealth spelling) is a type of engineered wood product that is made out of wood fibre. Types of fibre board (in order of increasing density) include particle board or low-density fibreboard (LDF), medium-density fibre board (MDF), and hardboard (high-density fibre board, HDF).

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USES

sound proofing/deadening,

structural sheathing,

low-slope roofing,

sound deadening flooring underlayment,

Fibreboard is also used in the automotive industry to create free-form shapes such as dashboards, rear parcel shelves, and inner door shells. These pieces are usually covered with a skin, foil, or fabric such as cloth, suede, leather, or polyvinyl chloride.

ARECANUT

Arecanut (Areca catechu L.), being a highly profitable commercial plantation crop. In view of this it is important to understand the package of practices to be followed in an arecanut garden and adopt the same for maximizing the returns. On an average, 5.5-6 tons of organic wastes/ha/year will be available in arecanut garden. Direct recycling of these waste does not meet the crop demand immediately. India is the largest producer of arecanut and at the same time largest consumer also. The major states cultivating this crop are Karnataka (40%), Kerala (25%), Assam (20%), Tamil Nadu, Meghalaya and west Bengal.

Arecanut is cultivated in an area about 1.53 lakh ha in Karnataka and it leaves behind enormous quantity of arecanut husk, leaf sheath, arecanut leaf. Thus, the disposal of arecanut waste is becoming a problem especially in the intensive arecanut growing areas. At present majority of arecanut waste is disposed of by burning which resulted into a loss of potential source of organic matter and valuable plant nutrients. The value of arecanut waste as organic material for compost making or incorporation in the field has not been fully realized in our country. In nature, much cellulose is protected from decomposition by the impregnation of lignin.

The fibres adjoining the inner layers are irregularly lignified group of cells called hard fibres and the portions of the middle layer below the outermost layer of soft fibres in Areca husk. Because of this reason arecanut wastes might require a combination of fungal species for collective degradation of lignocellulose

TANNIN: -

A tannin is an astringent, polyphenolic biomolecule that binds to and precipitates proteins and various other organic compounds including amino acids and alkaloids.

The tannin compounds are widely distributed in many species of plants, where they play a role in protection from predation, and perhaps also as pesticides, and might help in regulating plant growth. The astringency from the tannins is what causes the dry and puckery feeling in the mouth following the consumption of unripened fruit, red wine or tea. Likewise, the destruction or modification of tannins with time plays an important role when determining harvesting times.

Tannins have molecular weights ranging from 500 to over 3,000 and up to 20,000.

EXTRACTION

Measuring cylinder, china dish, pipette, beaker these are the equipment used for extraction of tannin and to achieve this 95% of Acetone was used as solvent.

The following steps are to be followed for extraction of tannin

- Step1: Add dried sample and solvent and vary the feed: solvent ratio from 1:20 to 1:30.
- Step2: Stir the solution in a beaker by varying the time from 45min to 75min.
- Step3: Filter the solution with filter paper.
- Step4: Take the residue and repeat the steps from 1-3, two times for high yield.
- Step5: Take the filtrate in rotary drier for tannin powder.
- Step6: Take the extracted tannin for tannin identification test.[1]

Fig no 1-Extracted tannin

TESTS FOR TANNINS

Ferric chloride test

Use of ferric chloride ($FeCl_3$) tests for phenolics in general. Powdered areca husk (1.0 g) is weighed into a beaker and 10 ml of distilled water are added. The mixture is boiled for five minutes. Two drops of 5% $FeCl_3$ are then added. Production of a greenish precipitate was an indication of the presence of tannins. Alternatively, a portion of the water extract is diluted with distilled water in a ratio of 1:4 and few drops of 10% ferric chloride solution is added. A blue or green colour indicates the presence of tannins.

Fig no 2-Ferric chloride test (bluish black colour)

FOURIER-TRANSFORM SPECTROSCOPY (FTIR)

Fourier-transform spectroscopy is a less intuitive way to obtain the same information. Rather than shining a monochromatic beam of light at the sample, this technique shines a beam containing many frequencies of light at once and measures how much of that beam is absorbed by the sample. Next, the beam is modified to contain a different combination of frequencies, giving a second data point. This process is repeated many times. Afterward, a computer takes all this data and works backward to infer what the absorption is at each wavelength.

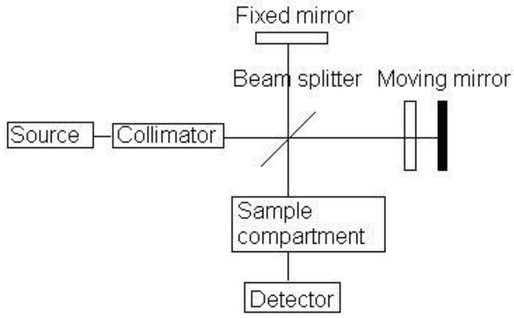

Fig no 3-Optical diagram of FTIR Spectroscopy

RESIN SYNTHESIS

Method for the synthesis of resin

TF resin was synthesized adopting the following procedure: 10g of extracted tannin was dissolved in 50 ml water, the PH of solution was adjusted to (10-11) by added some drops from 10% NaOH solution, the temperature of the solution raised to 80˚C with stirring for 75 min. Afterwards the solution was allowed to cool to 60˚C, then 40 ml from formalin solution was added, the temperature of the mixture was kept at 60˚C; the reaction time was about 3 hr. Tannin resins that synthesized consist of tannin-phenol formaldehyde (TPF), and TPF resins were synthesized by mixing the solution of predetermined weight of tannin with the amount of PF that give required proportion.[2]

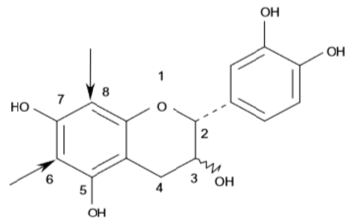

Fig no 4-Precursor of condensed tannin and reaction sites with formaldehyde

Fig no 5-TPF resin

EPOXY

Epoxy resins are a broad family of materials. The most common ones are prepared from the reaction of bis-phenol A and epichlorohydrin and contain a reactive functional group in their molecular structure. Epoxy resin systems show extremely high three-dimensional crosslink density which results to the best mechanical performance characteristics of all the resins. The most demanding strength/weight applications use epoxy almost exclusively. It has excellent strength and hardness, very good chemical heat and electrical resistance. Disadvantages include higher cost, processing difficulty (quantities of resin and hardener need to be measured precisely. Also, often heat curing is required.) Epoxy systems are used in applications like aerospace, defence, marine, sports equipment, adhesives, sealants, coatings, architectural, flooring and many others.

MILD STEEL MOLD

Dimensions :300*300*100 (mm)

Fig no 6-MS mould

PREPARATION OF PARTICULATE BOARD

1. Raw material prepared

2. Converted into particles

3. Particles dried

4. Particles classified

5. Blended with a resin

6. Particle/resin/additive blend ("furnish") is formed into a mattress

7. The particles were compressed in UTM machine at 360KN pressure.

Fig no 7 Adding of resin to raw material

Fig no 8 Compression of areca husk.

UNIVERSAL TESTING MACHINE (UTM) MACHINE

"A universal testing machine is used to test the tensile stress and compressive strength of materials. It is named after the fact that it can perform many standard tensile and compression tests on materials, components, and structures." This is very true, but perhaps overly simplistic.

The variety of terms in the industry that are used to refer to a UTM. Most common are "tensile tester", "compression tester" and "bend tester". There are also UTM's that have been stripped of capabilities or marketed to a specific sector which have led to the development of specialized names such as "texture analyser" for food, "top load compression tester" for packaging and pipe, and "peel tester" for adhesives, tapes, and labels. Today, a UTM can perform all of these tests and more. A UTM is a great multi-purpose instrument for an R&D lab or QC department.

Fig no-9 UTM Machine

Fig no-10 TPF board & Epoxy board

TESTS FOR PARTICLE BOARD

PROCEDURE FOR ALL TESTS[3]

TENSILE TESTING

Tensile Testing of Metals is a destructive test process that provides information about the tensile strength, yield strength and ductility of the material. Laboratory Testing Inc., near Philadelphia, PA in the United States, performs the tensile test in accordance with industry standards and specifications, including ASTM tensile test methods. This process is also known as a tensile strength test or tension test.

TENSILE TEST PROCESS

Tensile strength, also known as Ultimate Tensile Strength (UTS), is the maximum tensile stress carried by the specimen, defined as the maximum load divided by the original cross-sectional area of the test sample.

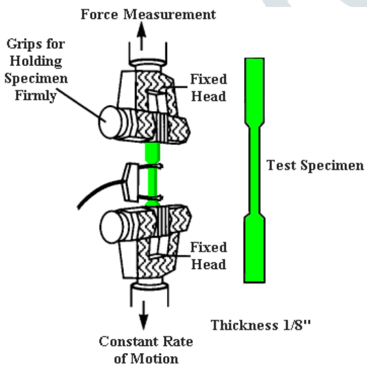

Fig-11 UTM arrangement for Tensile strength

BENDING MOMENT TEST

A **bending moment** is the reaction induced in a structural element when an external force or moment is applied to the element causing the element to bend. The most common or simplest structural element subjected to bending moments is the beam. beams can have both ends fixed; therefore, each end support has both bending moment and shear reaction loads. Beams can also have one end fixed and one end simply supported. The simplest type of beam is the cantilever, which is fixed at one end and is free at the other end (neither simple or fixed). In reality, beam supports are usually neither absolutely fixed nor absolutely rotating freely.

SI. no	PARTICUALTE BOARD SIZE	No of specimens	Testing Property
1	300*300*15mm	3	1)Tensile test (ASTM D 3039) 2)Bending properties test (ASTM D 790) 3)Density (ASTM D 792) 4)Water absorption 5)Swelling 6)Electrical conductivity

Fig no 12 Bending of material.

DENSITY

The ratio of the mass of a substance to its volume is known as the mass density or, simply, the density of the substance. Density is expressed in units of mass per volume, such as g/mL or kg/m^3. Because the density of a substance does not depend on the amount of substance present, density is an "intensive property".

To measure the density of a sample of material, both the mass and volume of the sample must be determined. For solids, a balance can be used to measure mass. The volume of a solid can be measured by submersion in a liquid — the difference in volume caused by addition of the solid is equal to the volume of the solid.

WATER ABSORPTIVITY

Water Absorptivity Test Two samples were taken from each mass fraction, weighed, and soaked in water for 24 hours. Thereafter, they were removed from water, cleaned, dried, and re-weighed. The obtained data were recorded against each mass fraction. The percentage water absorptivity was also calculated and recorded against each mass fraction. The percentage water absorptivity was calculated

Percentage of Water Absorptivity = (Final Weight – Initial Weight) / Initial Weight × 100.

SWELLING TEST

BEAKER TEST METHOD

In this method

- A small amount of superabsorbent polymer material is taken (0.1g) and it is placed in the beaker.
- 100 ml of deionized water is poured into the beaker.
- After 20 min the swollen polymer was separated by using [filter paper]
- By weighing the polymer, one can find the swollen capacity of the SAP material.

ELECTRIC CONDUCTIVITY

Electrical Conductivity Test Electrical conductivity is a physical property that indicates how well a given material conducts electricity. The test was performed to check the electrical conductivity of the material. The electrical circuit used to check the electrical conductivity is shown below.

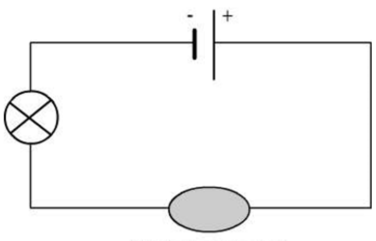

Fig no 13 Electric conductivity for particulate board

The negative terminal of a battery is connected directly to the blub. A wire from the positive terminal of the battery is connected to the rice husk board. Another wire is connected between rice husk board and the bulb. If the board conducts electricity the bulb must glow. On conducting the experiment, the bulb failed to glow, which proves that the rice husk board does not conduct electricity. This property of non-conducting nature makes it useable for switch boards, electrical circuits etc.

FTIR ANALYSIS

The tannin extract was examined in order to better compare the fraction resulting from with those resulted from standard tannin. For the standard tannin, that must contain components able to mask certain absorption bands, a spectra deconvolution was imposed. The IR spectra of the standard tannin and of the tannin extract contain bands that can be assigned to the ellagic acid, the main constituent. The ketonic group valence vibration C=O is located at 1694 cm-1 in the pure tannin extract spectra, and at 1710 cm-1 for the standard tannin spectra (probably due to the participation in other bonds). The ≡C-H group vibrations C-H are centred at 2990 cm-1 for the tannin extract and at 2928 cm-1 for the standard tannin. The symmetrical and asymmetrical C-O valence vibration appears at 1366 cm-1 and at 1056 cm-1 respectively for the tannin extract and at 1322cm-1 and 1083 cm1 respectively, for the standard tannin. The vibrations assigned to aromatic rings are located between 1617 cm1 and 1451 cm-1. Both characteristic absorption peaks of the tannin extract and standard tannin can be observed in the FTIR spectrum of the of areca husk tannin extract indicating that tannin is mainly present in the area husk.

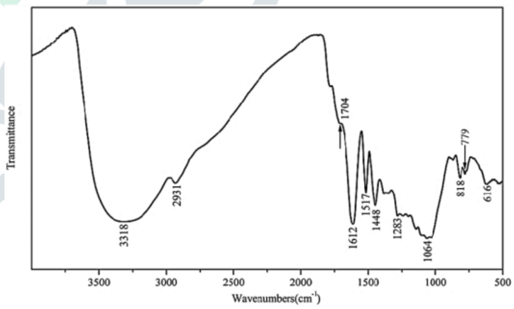

Fig no 14 FTIR Spectrum for standard tannin.

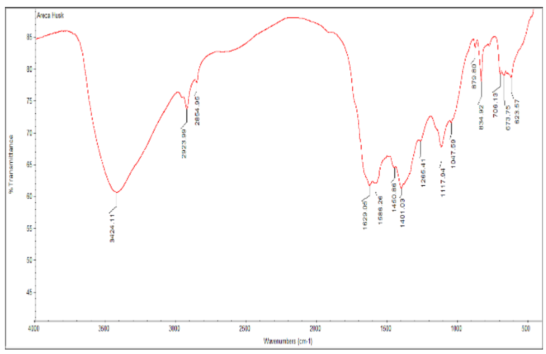

Fig no 15 FTIR Spectrum for extracted tannin from areca husk.

The symmetrical and asymmetrical C-O valence vibration appears at 1366 cm-1 and at 1056 cm-1 respectively for the tannin extract and at 1322cm-1 and 1083 cm1 respectively, for the standard tannin. The vibrations assigned to aromatic rings are located between 1617 cm1 and 1451 cm-1.

RESULTS AND DISCUSSION

TENSILE STRENGTH

Table no 2 For TPF board

S. No.	Dimensions (mm)	Tensile stress (MPa)	Remarks
1.	250×25x15	99	Splitting
2.	248x25x15	100	Fracture
3.	244x25x15	98	splitting

Table no 3 For epoxy-resin board

S. No.	Dimensions (mm)	Tensile stress (MPa)	Remarks
1.	250×25x15	122	Fracture
2.	248x25x15	118	splitting
3.	244x25x15	120	splitting

Two different boards which were manufactured were cut and tested as per ASTM std. on comparison we got to know that the average tensile strength of TPF based board was 99.01 MPa. Whereas the tensile strength of epoxy board was 120 MPa. It is concluded that TFP resins have bit low bonding strength compared to epoxy. The results were satisfactory.

Fig no 16 UTM machine for tensile strength

BENDING PROPERTY

SI NO	DIMENSIONS (mm)	MAX DISP (mm)	MAX LOAD (kN)	Resin boards
1	130x1.3	11.70	4.4	TPF
2	130x1.3	18.90	3.04	TPF
3	130x1.3	17.70	3.99	TPF
4	130x1.3	10.50	5.8	EPOXY
5	130x1.3	12.50	4.58	EPOXY
6	130x1.3	13.20	5.05	EPOXY

Table no 4 For both TPF & epoxy-board

For this particular test we used the same UTM machine but modified for bending test. There were 3 specimens test for each board. The average load at which the specimen splits was 3.99 kN for TPF board and 5.14 kN for epoxy board.

DENSITY TEST

Table no 5 For TPF based board

SI NO.	DESCRIPTION	1	2	3	AVERAGE DENSITY
1	SAMPLE WEIGHT IN AIR	17.89g	18.00g	18.25g	
2	Volume of water displaced	22ml	23ml	22ml	808.24
3	Density	813.18	782	829.54	

SI NO.	DESCRIPTION	1	2	3	AVERAGE DENSITY
1	SAMPLE WEIGHT IN AIR	15.88g	15.55g	16g	
2	Volume of water displaced	24ml	25ml	25 ml	641.2
3	Density	661.6	622	640	

Table no 6 For epoxy-based board.

The average density of TPF board was 641.2 kg/m^3. which falls in category of low density board and the average density for epoxy board was 808.24 kg/m^3. Which falls in the category of medium density board.

WATER ABSORPTION

For TPF based board,

Initial weight = 15.65g

Final weight =16.23g

Percentage = (16.23-15.65)/15.65 × 100 = 3.7 %

For epoxy-based board,

Initial weight = 15.95 g

Final weight =16.45g

Percentage = (16.45-15.95)/15.95 × 100 =3.1%

SWELLING TEST

1. Swelling thickness for TPF board = 1.82mm
2. Swelling thickness for epoxy board =0.9 mm

CONCLUSION

In this project, a particulate board is manufactured from areca husk using suitable bio and synthetic resins. The main advantage of this project is that the product is eco-friendly and cost-effective compared to boards manufactured using other materials. It also helps to convert the agricultural wastes into useful particulate board. The manufacturing process is quiet simple and cost-efficient. In conclusion we can say that the board which are manufactured using bio and synthetic resins can be used for different applications.

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