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# Effect of CissusPopulnea and Synthetic (Poly Vinyl Acetate) Adhesive on Physico-Mechanical Properties of Particle Boards Produced from Sida Acuta

**Toyin Akinbosoye**

***Abstract:** This study investigated the properties of particle boards produced from composite of renewable lignocelluloses particles of sidaacuta plant, a non-toxic environmental friendly adhesive processed from extracted mucilage of cissuspopulnea stem and a commercial synthetic adhesive poly vinyl acetate.Cissuspopulnea adhesive and poly-vinyl adhesives were used as treatment at percentage mixing ratio of 0 and 20, 5 and 15, 10 and 10, 15 and 5, 20 and 0% by weight of total resin in the binding of processed sida acuta particles for the production of particle boards. 24 samples of dimension 150mm x 50mm x 10mm were produced in processing order of mixing, mat formation, hot pressing, air curing and trimming, thereafter subjected to flexural strength and physical tests to determine the boards Modulus of Rupture (MOR), Modulus of Elasticity (MOE), Internal Bonding strength (IB), Moisture Absorption capacity (MA) and Density of the boards.The mean of the data obtained from the tests conducted on the particle boards were tabulated and statistically analyzed using descriptive charts and ANOVA. Results obtained revealed that the board MOE, MOR, IB, MA and Density range between 18.6N/mm$^2$ - 66.8N/mm$^2$, 0.135N/mm$^2$ - 0.365N/mm$^2$, 0.56 X 10$^{-3}$ N/mm$^2$ - 1.31 X 10$^{-3}$N/mm$^2$, 9.4% - 12.3%, 0.40g/cm$^3$ - 0.50g/cm$^3$ respectively and Analysis of Variance showed no significant difference (P > 0.05) in the physical and mechanical properties of the boards at the percentage levels of treatments used. These results confirmed the suitability of sida acuta particles and cissuspopulnea adhesive as potential materials for the manufacturing of particle board, which implies that sida acuta particles can be used as substitute for non-available or non-renewable lignocelluloses particles while cissuspopulnea can partially or fully replace synthetic (poly vinyl acetate) adhesive to enhance production of low cost particle boards. This work therefore recommend further research on the use of cissuspopulnea adhesive as substitute for other commercial base synthetic adhesives used for particle board production*

***Key words:** Sida Acuta, Synthetic Adhesive, CissusPopulnea, Flexural Strength, Physical Test*

## I. INTRODUCTION

Adhesives are used daily in wood furniture and wood based products industries for manufacturing wood products such as plywood, particle board, fibre board, oriented strand board and other laminated veneer products universally used for various applications.

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*** Correspondence Author**
**Toyin Akinbosoye**,Federal College of Forestry Jericho Ibadan.



Adhesives are polymeric substances that join one material to another and capable of interacting physically, chemically or both to cause surface adhesion or cohesion in such a way that stresses are transferred between bonded members without rupture or detachment of the adhesives from the materials (Auge, 2008). Adhesives can either be synthetic or natural. Synthetic adhesives are manufactured from industrial raw materials that are not renewable, they include resin mainly based on urea melamine, phenols, resorcinol, epoxy and other unsaturated polyester. Although these adhesives had been proved to possess better performance but have shortcomings of renewability and safety, including high cost of purchase, especially when needed in large volume.Natural adhesives such as starches, dextrin's, natural rubber are regularly used when making wood composites until the mid - twentieth century before attention was shifted to their synthetic counterparts. Some of the numerous advantages of natural adhesives are renewability source, environmental friendly, and ease of manufacturing in large volume with cost efficiency, meanwhile their bonding properties can also be substantially improved. Natural adhesive from plant sources are commonly processed from agricultural produce such as rubber, cassava etc., but can also be processed from *Cissuspopulnea*plant. This plant belongs to the family *Amplidaceae Vitaceae*. It is a 2m– 3m high semi-climber which grows in the savannah and widely distributed in Senegal, Sudan, Uganda, Abyssinia and Nigeria (Hutchinson and Dalziel, 1958).The important quality index of *Cissuspopulnea* gum regarded as hydrophilic polymer is the degree of gelling and cohesiveness, lack of toxicity, regulatory acceptance and cost effectiveness (Adeleye et al., 2011). The flow index does not show major change with temperature hence said to exhibit pseudo plastic behaviour (Alkali et al. 2009). Both apparent and consistency index were found to increase with increasing temperature below its boiling point and decreased above the boiling point 70$^0$C which is attributed to interconnected structural differences in the polymer. Amalime (2007) reported that C.*Populnea*has strong inter particulate cohesive bonds which makes it a potential substitution for other expensive binder commonly used in tablet formulation.

Particle board is a wood based panel products widely used for various applications. They are used for furniture work, interior roofing and flooring, drawing boards, chalk boards etc., and also become an enviable wood based products when laminated. They are manufactured from lignocelluloses materials in the form of discrete particles primarily processed from wood log or saw mill waste obtained in the form of wood shavings, saw dust, strands, and flakes combine with synthetic resins or other suitable binder and bonded together under heat and pressure, or cold press when heat is not needed or when bonded with inorganic adhesive such as cement. Over the years there has been competition over the utilization of wood waste generated in saw mills among rural and urban dwellers for various commercial purposes such as cooking, bedding or absorbent materials in livestock pen and houses which led to scarcity of the waste material thus negatively affecting wood waste utilization in the production of particle boards. In recent development to reduce these menace, scholars have explored agricultural materials as a substitute for wood waste. The use of maize stalk was explored by (Ajayi, 1982) as a substitute for wood waste in the manufacturing of cement- bonded particle board. Thus, this study focused on determining the effect of CissusPopulnea and Synthetic (Poly Vinyl Acetate) Adhesives on Physico-Mechanical Properties of Particle Boards Produced from SidaAcutawith synthetic adhesive (poly vinyl acetate) as a binder.

## II. MATERIALS AND METHODS

### *2.1 CissusPopulnae Adhesive Formulation by Water Extraction*

*Cissuspopulnea* stems were sourced from a local market in Ibadan south west local government and processed in the pharmaceutical laboratory of Forestry Research Institute of Nigeria. The stems were crosscut into 6cm billets, washed with clean water and weighed using suprema S.V. weighing balance. 16kg of the billets were soaked in 32 Liters of distilled water with 5ML of chloroform per 200ML of water added as preservative, and allowed to stay for 72 hours for mucilage extraction. The extracted mucilage was sieved to remove water and oven dried in a Gallenham oven at a temperature of 60$^0$C. The dried mucilage in the form of crumbs was removed from the oven and grounded into powder with the aid of a blender. The powder was further sieved with 18µm sieve to obtain more consistent fine powdered which was stored at room temperature prior usage

**Table 1.0 Properties of *cissuspopulnea* adhesive**

| Parameter | Physical Properties |
|---|---|
| Particle size | 18µm |
| Phase of adhesive | Powdery |
| Methods of preparation | Water soluble |
| Colour | Reddish brown |
| Stain | Non – staining |
| Form of application | paste |

### *2.2 Sida Acuta Particle Preparation*

*Sida acuta* is an agricultural fibrous plant which is renewable and naturally occurring as weed, therefore making it abundant in nature and readily available. Collected stems of the plant obtained from Federal College of Forestry field were weighed, cut into 3cm long, milled and oven dried to a moisture content of 12%, thereafter was sieved to 600µm-800µm particles sizes for board production.

### *2.3 Synthetic Adhesive Procurement*

Poly - Vinyl acetate (Fevicol SH) was procured from adhesive producing company located in Oluyole industrial estate Ibadan. Nigeria. The adhesive is non-flammable and non-toxic milky white paste mostly used as binder in commercial wood furniture manufacturing industries and in the production of light weight laminated engineered wood products.

### *2.4 Particle Board Production*

#### *2.4.1. Determination of particle board Constituents by Weight*

The particleboard samples were produced in the proportion of 15% resin and 85% fibre content. Medium density particle board of 0.8g/cm$^3$ and dimension 15 x 5 x 1(cm$^3$) was proposed. Equation 1, 2, and 3 were used to determine the mass of the board and the constituents.

-----------------------------------------------------equation (1)

0.8g/cm$^3$= mass (g) / 15cm x 5cm x 1cm

Mass of board (g) = 60g

Using 15% Resin content

Mass of resin = 15% of the mass of board (60g)

Mass of resin = Mass of Synthetic Adhesive + Mass of *CissusPopulnea* Adhesive = 12g-----equation (2)

Mass of fibre = mass of board - mass of resin-------------------------------------------------------equation (3)

Mass of fibre= (60-12) g = 48g

#### *2.4.2 Mat Formation*

The weight of each constituent that form the board was determined using electronic weighing machine and the constituents were thoroughly mixed according to mixing proportion in Table 2.0 to obtain particle board furnish. This furnish was poured and uniformly spread into six compartment iron mold for mat formation. The mold was design to allow production of 6 boards of (15 x 5 x 1) cm$^3$ at a time and four replicates per treatment were produced.

**Table 2.0 Treatment by composite mixing ratio for the particle boards production**

| Treatments | Mixing Ratio byWeight (g)CPA:SNA:SAP | Mixing Ratio by % CPA:SNA:SAP | Total weight of Particle board Furnish (g) |
|---|---|---|---|
| T1 | 0 : 12 : 48 | 0 : 20 : 80 | 60 |
| T2 | 3 : 9 : 48 | 5 : 15 : 80 | 60 |
| T3 | 6 : 6 : 48 | 10:10 : 80 | 60 |
| T4 | 9 : 3 : 48 | 15 : 5 : 80 | 60 |
| T5 | 12: 0 : 48 | 20 : 0 : 80 | 60 |

**CPA**-*CissusPopulnea* Adhesive. **SNA**-Synthetic Adhesive. SAP-*Sida Acuta* Particles

### *2.4.3 Pressing and De-molding*

The particle boards furnish spread in the mold were hot pressed for 10 minutes at a temperature of 150$^0$C and pressure of 2.5bar after which they were removed and Cooled under ambient temperature. 24 samples were produced and evaluated to determine their flexural strength, internal bonding strength, moisture absorption capacity and density.

### *2.5 Flexural Strength Test (Mechanical properties)*

3 point Flexural bending test was carried out in accordance with ASTM D 1037 by Universal Testing Machine (600KN capacity) to determine the Modulus of Rupture (MOR), Modulus of Elasticity (MOE) and internal bonding strength (IB) of the boards. Each sample was loaded at the rate of 2mm/min at the mid span of 100mm until failure occur. The parameters obtained from the test were used to determine the flexural properties of the boards using equation 4, 5 and 6.

**$^2$ ($^2$)** ------------------------------------------------------------------ --------- equation 4

$_1^{332}$------------------------------------------------------------------------ -----equation 5

$^2$------------------------------------------------------------------------ --------------equation 6

= maximum load (N)
= load at proportional unit (N)
= width of the specimen (mm)
= thickness of the specimen (mm)
= deflection at mid-point (mm)
= span of specimen (mm)

### *2.6 Physical Properties Test*

### *2.6.1 Moisture Absorption Capacity (%)*

The samples were conditioned for 24 hour by covering them with wet cloth in a control chamber at 60% relative humidity and the probe of a digital hygrometer was inserted in the chamber to monitor the R.H After 24 hours the samples were removed from the chamber and oven dried to a constant mass at temperature of 105±5$^0$C. Equation 7 was used to determine the moisture absorption capacity.

**X 100** ---------------------------------------------------------------- ------------ equation 7

= weight of conditioned sample before oven-dried

= weight of oven dried sample

### *2.6.2 Board Density*

Each board was weighed to determine the mass, while the volume was determined from the dimension **150mmx 50mm x 10mm** of the boards. The density of each board was determined using equation 8.

---------------------------------------------------------------------- ----equation 8

### *2.7Data Analysis*

All the data obtained were tabulated and subjected to descriptive and statistical analysis using bar chart, Analysis of variance ($p < 0.05$) to test the significant level of the treatments on the mechanical and physical properties of the particle boards.

## III. RESULTS AND DISCUSSION

### *3.1 Results*

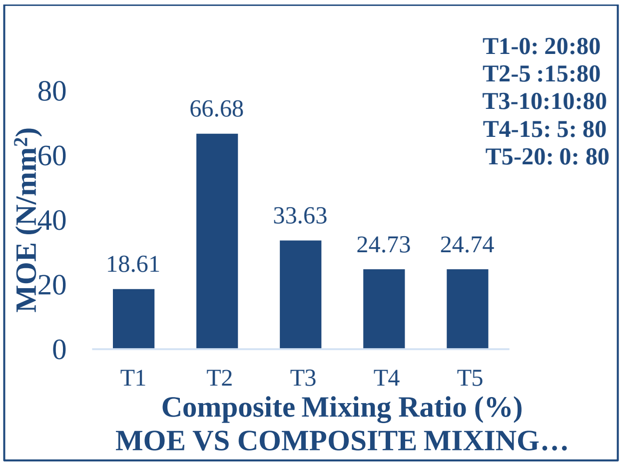
### *3.11 Mechanical and Physical Properties*

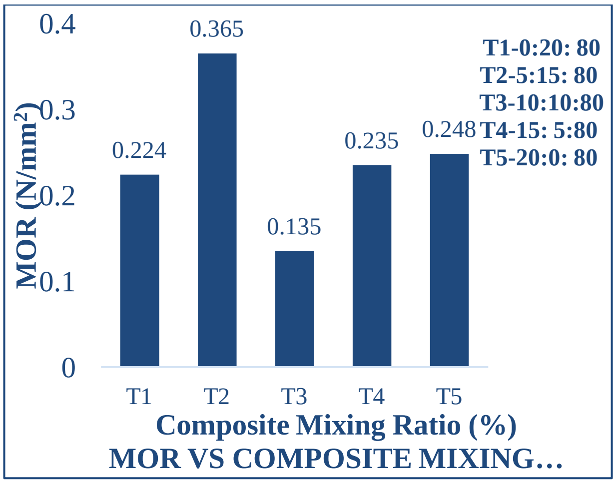
The results of the Mechanical and Physical properties of the particle boards are shown in the Table 4.0 and graphically represented in Figure 1-5

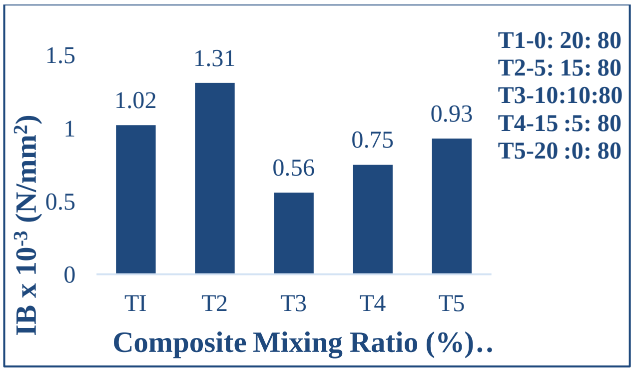
**Table 4.0: Mean Values of the Physical and mechanical properties of the particle boards**

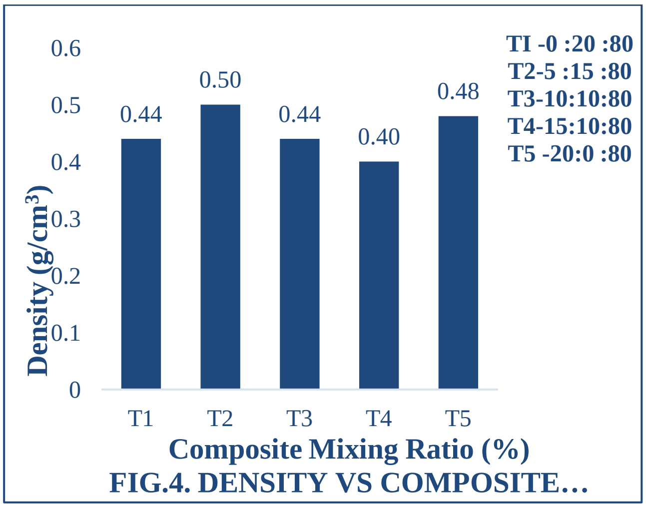
| CPA: SNA: SAP (%) | MOE (N/mm$^2$) | MOR (N/mm$^2$) | IB x 10$^{-3}$ (N/mm$^2$) | Density (G/cm$^3$) | Moisture Absorption (% |
|---|---|---|---|---|---|
| 0: 20:80 (T1) | 18.61 | 0.224 | 1.02 | 0.44 | 9.4 |
| 5: 15:80 (T2) | 66.68 | 0.365 | 1.31 | 0.50 | 10.2 |
| 10:10:80 (T3) | 33.63 | 0.135 | 0.56 | 0.44 | 12.3 |
| 15: 5: 80 (T4) | 24.73 | 0.266 | 0.75 | 0.40 | 12.1 |
| 20: 0: 80 (T5) | 24.74 | 0.248 | 0.93 | 0.48 | 12.5 |

**CPA** - *CissusPopulnea*. **SNA** - Synthetic Adhesive **IB**- Internal bonding strength



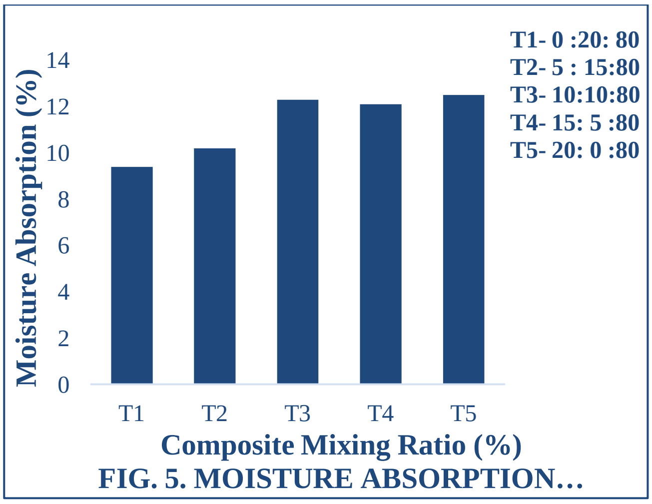




**Table 5.0: Analysis of variance of the particle board mechanical and physical properties**

| Source | MOE | MOR | IB | Density | MA |
|---|---|---|---|---|---|
| Mixing Ratio | ns | ns | ns | ns | ns |

**Note: ns not significant at 5% level of probability.**

## IV. DISCUSSION

Theresults in Table 4.0 showed the values of MOE, MOR and IB, densities and moisture absorption capacities of the manufactured boards as obtained from mechanical and physical properties tests. Modulus of elasticity (MOE) depicted in FIGURE 1 is the ability of the board to regain its original shape and size after being stressed and thus determined its flexibility and stiffness, the values range between 18.61N/mm$^2$ and 66.68 N/mm$^2$. The highest and least MOE was obtained at composite mixing ratio T1 and T2 respectively. The board modulus of elasticity exhibited sinusoidal increase as *cissuspopulnea* adhesive increases from 0% to 20% in the mixing ratio, which as a result may influence the flexibility and stiffness of the board. These behaviour may be attributed to internal bonding strength which varied at different mixing ratio, as also reported by Alao (2011), on the evaluation of *cissuspopulnea* as a potential for particle board manufacture.

Modulus of Rupture is the maximum bending strength as a result of stress in the extreme fibrous particles of the board, occurring at the point of failure. The values range between $0.135N/mm^2$ and $0.365\ N/mm^2$. The board of adhesive ratio T2 recorded the highest MOR of $0.365N/mm^2$ while T3 had the least MOR of $0.135N/mm^2$. The MOR of the board increases simultaneously as the percentage *cissuspopulnae* adhesive increases in the board composition from 0% to 5%, and 10% to 20% which thus revealed that the adhesive content may influence MOR of the board to exhibit high bending strength. These findings also correlate with that of Alao 2011.

Internal bonding strength of the boards range between $0.56 \times 10^{-3}\ N/mm^2$ and $1.31 \times 10^{-3}\ N/mm^2$. The least and the highest IB strength was obtained at T3 and T2 adhesives ratio respectively. It increases between T1 and T2, decline between T2 and T3 and further increases between T3 and T5 as the percentage of*cissuspopulnea*adhesive increases from 10% to 20%. Alao, (2011) reported IB strength of $0.01N/mm^2$ for 3- layers particle boards higher than $1.31 \times 10^{-3}\ N/mm^2$ of the single layer board produced in this research work.. This may be due to the board multiple layers which will require higher adhesive content for the board formation. It implies that IB strength is a function of the percentage adhesive by weight of the composite. The physical properties are moisture absorption and density. Moisture absorption capacity is one of the factorthat influences selection of particle board for either interior or exterior application. The values range between 8.0% and 12.3%, the least was recorded at T1 while it was maximum at T3 of 10% *cissuspopulnea* adhesive composition in the board. The results of the board moisture absorption in Fig 5 showed a linear increases with increased percentage of cissus*populnea* adhesive. This behaviour may be attributed to affinity nature of natural adhesives for moisture absorption. The density of the board is of value ranging between $0.43g/cm^3$ and $0.50g/cm^3$, this values falls within recommended standard range for low density boards i.e density $\leq 0.50g/cm^3$. Analysis of variance (ANOVA) at $p > 0.05$ of the mean values obtained from the physical and mechanical test as shown in Table 3.11 revealed that, there is no significant difference in the mechanical and physical properties of the boards at all percentage levels of the composite mixing ratio.

## V. CONCLUSION

The results of the properties of the particle boards produced in this research work, compared with that of conventional particle boards revealed and confirmed the potential and compatibility of using *sida acuta* particles and *cissuspopulnea* adhesive in the production of low or medium density particle boards suitable for construction purpose in both interior and exterior application.

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