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An Assay of some Thermal Characteristics, Chemical and Phytochemical Constituents of *Hymenocarida Acida* Timber

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ABSTRACT: Timber has always played an influencing role in human lives. The quality of timber and its behavior in response to fire depends on many parameters. As a result *Hymenocardiaacida*wood was studied in terms of thermal, chemical, physical and variable techniques. The results obtained were as follows: afterglow time 58.33sec, flame duration 271.67sec, flame propagation rate $4.4x10^{-2}cm.s^{-1}$, ignition time 3.67sec, thermal conductivity14.37 x 10^{2}Umoh/cm, electrical conductivity $4.4x10^{-3}Sm^{-1}$, ash content 0.95%, moisture content 12.67%, oven dry density $78.7x10^{-2}g.cm^{-3}$, water imbibitions (at different time intervals: 30mins 11.1%, 5hrs 13.8% and 24hrs 22.3%), etc, These results showed it to be a good timber suitable for various construction purposes. Phytochemical screening showed the presence of saponins, tannins, steroids, flavonoids, carbohydrates, proteins, resins, terpenoids, glycosides and alkaloids. The Atomic Absorption Spectrophotometer (AAS) of the sample showed the presence of some metals such as Na, K, Pb, Ca, As, Zn, Mg, and Cu in the decreasing order of their concentrations. The thin layer chromatographic analysis of the chloroform and chloroform-methanol extracts which gave three spots with Rf values of 0.7, 0.6 and 0.5 was further characterized using Fourier Transform Infrared and Ultraviolet Spectroscopic methods. The Fourier Transform Infrared and Ultraviolet spectra suggested a 1, 2, 3- trisubstitutedphenylamide with OH, CO and CN groups attached as the functional groups present. The chemical components analysis showed the presence of cellulose, hemicelluloses, lignin and other constituents in their right proportion. The results provided the required information on the properties of *Hymenocardiaacida*wood. It also confirmed the efficiency of the wood for various construction purposes and its medicinal ability due to the presence of the secondary metabolites.

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***Keywords*:** Timber, *Hymenocardia acida,* Functional group analysis, Phytochemical, thermal andchemical constituents.

Hymenocardia acida is a plant of the Phyllanthaceae family native to tropical Africa. In Nigeria, its Igbo name is ikalaga, orupa in Yoruba and janyaro in Hausa. It is a hardwood mostly located at Enugu and Awka (Arbonnier, 2004; Keay,1989)

Hymenocardia acida is a deciduous shrub or small tree growing up to 10 metres tall, often looking gnarled and twisted with a characteristic rough rusty-red bark. A tree of the tropics, found at elevations of 500 - 1,200 metres, growing in areas that experience a long dry season. It succeeds on sandy, loam and clayey soils (*Dressler et al.,*2014).

The plant is especially valued for its medicinal virtues in Africa, where a decoction of the leaves, combined with honey, is used to treat coughs, stomach aches and biliousness. The vapour of the boiling leaves is inhaled to treat headache. The leaf powder is also added to food as a treatment for asthma. The plant also provides food, wood and tannins for local use and is sometimes planted to prevent soil erosion (Arbonnier, 2004). Its young leafy shoots could be used as a supplementary food, an acid flavor and the fruit is edible and is sometimes eaten. The bark, leaves, leafy shoots and roots have a considerable range of medicinal uses in Africa. In Kenya and in Uganda the wood is known for its hardness, denseness, durability and good resistance to termite-attack. It is used to make pestles and bark-cloth mallets. (Desch and Dinwoodie, 1981)

Wood is a major building material that is renewable and replenish able in a continuous cycle. The demand for tropical woods is growing. Timber is a type of wood that has been processed into beams and planks used for structural purposes and, many other uses as well. Trees provide a huge variety of products for humanity. However, it is their timber that provides the greatest contribution in terms of income. (Arntzen, 1994) Different trees species provide timber with varying strength, durability, resonance, colour and scent. As a result, only certain tree species are suitable for a given purpose or end use, be it for building materials, veneers, furniture, musical instruments, and others. (Eboatu and Altine 1991) The global demand for timber has put huge pressure on the wild populations of particular tree species.

There are insufficient information on the wood of *Hymenocardiaacida,* therefore, some thermal and variable properties, chemical constituents, phytochemical and functional group assay of the wood were investigated, also determining its suitability.

MATERIALS AND METHOD

Sample Collection and Identification: Hymenocardia acida timber was collected from timber shed at Awka in Awka North Local Government Area of Anambra State. Timber dealer, forest officer (Mr. Vin Okakpu of Nnewi Forestry) as well as literature (Keay *et al.,*1989) helped in the timber identification.

Sample Preparation: Hymenocardia acida timber was cut in a saw mill into two different shapes and sizes; dust from the timber was also collected. The timber was cut into splints of dimensions 30 x 1.5 x 0.5cm and cubes of dimensions 2.5 x 2.5 x 2.5cm. The samples were dried in an oven at 105^{o}C for 24 hours before the experiments.

Methods: Characterization of Thermal Properties: Afterglow time, flame duration, flame propagation, ignition time, oven dry density, moisture content, water imbibitions, ash percentage, specific gravity, porosity index, thermal conductivity and electrical conductivity were variously determined using American Society for testing and material (ASTM) methods (1998 & 1999) and as described by Eboatu and Altine (1991). Each experiment was repeated three times and the results averaged. The microelement composition was analysed using atomic absorption spectrophotometer model PG 990 manufactured by PG instrument Ltd U.S.A.

Characterization of Phytochemical Constituents: resins, steroids, terpenoids, tanins, alkaloids, saponin, flavonoids, glycosides, phlobatannins, carbohydrate and protein were qualitatively and quantitatively determined by the methods outlined by Harbon (1998).

The hydrogen ion concentration (PH) was determined by the method outlined by Amadi *et al.*(2004) using electrical PH meter PHS-25 made by Life Care England.

Characterization of Chemical Constituents: lignins, hemicellulose, cellulose, crude fibre, crude protein, carbohydrate, phenol and destructive distillation of the wood products were quantitatively determined by the methods outlined by Goering, Vansoest (1975), Oakley (1984) and Marzie (2010).

The chloroform-methanol and chloroform extracts were monitored using TLC, Fourier Transform Infrared and Ultraviolet Spectroscopic methods.

RESULTS AND DISCUSSION

The results of the solubility, physical, thermal investigations and the analysis of the active constituents present in the timber extract of *Hymenocardia acida* are given in tables 1- 9.

Table 1: Solubility Property of *Hymenocardia acida* Timber

Solvents	Results
Hot and cold water	Insoluble
1.0M Dilute HCl	Insoluble
Concentrated HCl	Insoluble
Concentrated HCl + heat	Slightly Soluble
1.0M Dilute H_2SO_4	Slightly Soluble
Concentrated H_2SO_4	Slightly Soluble
Concentrated H_2SO_4 + heat	Soluble
1% NaOH	Insoluble
Ethanol	Insoluble
Diethyl ether	Insoluble

The solubility analysis showed that *Hymenocardia acida* powder completely dissolved only in the presence of heated concentrated tetraoxosulphate (vi) acid. Therefore, the sample is resistant to polar, organic and corrosive substances except highly corrosive hot acid. This is in line with Petterson, (2007) who stated that chemicals are able to extract some extraneous materials in wood, yet woods are highly resistant to them and as such cannot be degraded by the chemicals.

Table 2: Thermal and physical characteristics of *Hymenocardia acida* Timber

Characteristics	Units	Results
Afterglow time	Sec	58.33
Flame duration	Sec	271.67
Flame propagation rate	$cm.s^{-1}$	4.4×10^{-2}
Ignition time	Sec	3.67
Over dry density	$g.cm^{-3}$	78.7×10^{-2}
Moisture content	%	12.67
30 mins Water imbibitions	%	11.1
5 hrs Water imbibitions	%	13.8
24 hrs Water imbibitions	%	22.3
Ash Content	%	0.95
Thermal conductivity	Umoh/cm	14.37×10^{2}
Electrical Conductivity	Sm^{-1}	4.4×10^{-3}
Specific Gravity		0.33
Porosity Index	%	1.90
PH		6.55
Colour		Wheat

Thermal characteristics analysis showed that it had high flame duration value of 271.67seconds which indicated that it could sustain itself till the whole length of wood got burnt. Afterglow time value of less than four minutes (58.33seconds) showed that it would not glow long enough for rekindle to take place as a result would be less hazardous in fire situations. A Flame propagation rate value of less than 0.28 $cm.s^{-1}$ indicated that the timber is fire-tolerant. Water imbibitions at 30 mins, 5 hrs and 24 hrs intervals with respective values of 11.1%, 13.8% and 22.3% showed the capacity of *Hymenocardia acida* wood to absorb water over a period of time (Udeozo, *et al*., 2014). The oven dry density and ash content values are in line with the ascertain of Desch

and Dinwoodie (1981) which stated that dense and small ash content timbers are suitable in their use as a source of carbondioxide for internal combustion engine. The result indicated that *Hymenocardia acida* is a hardwood that will be very good for construction and other purposes.

Table 3: Phytochemical composition of *Hymenocardia acida*Timber

Class of phytocompounds	Inference
Saponin	+
Flavonoids	++
Steroids	++
Terpenoids	+
Tannin	++
Alkaloids	++
Carbohydrate	+
Protein	++
Glycosides	+

Key: +++ = highly present; ++ = moderately present; + = slightly present; - = absent

Phytochemical analysis revealed the presence of all the tested secondary metabolites which includes; flavonoids, alkaloids, saponin, protein, resins, tannin, steroids, terpenoids, glycosides and carbohydrate. The medicinal values of medicinal plants lie on these phytocompounds which produce definite physicological actions in human body. Flavonoids exhibit an anti-inflammatory, anti-allergic effects, analgesic and anti-oxidant properties (Dunguid, *et al,.*1989). The presence of alkaloids showed that it can be used as antimycotics and also in the treatment of stomach pains (Akpuaka, 2009). Saponin has been found to be anti-carcinogenic, cholesterol reducer and anti-inflammatory substance. Tanins are anti-inflammatory, control gastritics and irritating bowel disorders, they also contribute to antimicrobial power which heals wounds and stop bleeding (Gills, 1992). Steroids are used in medicine for treatment of diseases. Terpenoids are associated with anti-cancer and also play a role in traditional and alternative medicine such as aromatherapy, antibacterial and other pharmaceutical functions. Resins are valued for their chemical properties and associated uses as the product of varnishes, adhesives and food glazing agents. Protein indicated high nutritional value of the extract, therefore can help in physical and mental growth and development (Dunguid et al., 1989)

Table 4: Micro elemental composition % of *Hymenocardia acida* Timber

Zinc	0.18
Lead	0.43
Cadmium	Nil
Copper	0.01
Sodium	2.27
Calcium	0.31
Magnesium	0.01
Potassium	1.10
Arsenic	0.23
Mercury	Nil

Atomic Absorption Spectrophometric analysis of the sample showed the presence of sodium, potassium, calcium, magnesium, copper and zinc which are beneficial to healthy adults at normal intake levels. Sodium and potassium play important role in maintenance of osmotic, electrolytic balance and proper rhythm of clothing (Tahir*et al*., 1999). Magnesium is for signaling the nervous system and also participates in osmotic and electrolyte balance but can cause genetic disorder (Konrad, and Weber, 2003). Copper is also involved in body enzymatic activities while zinc is required for growth, sexual development, wound healing infection, sense of taste and night vision in human (Maret and Sandstead, 2006). Lead and arsenic were also present while mercury and cadmium were absent.

Table 5: Quantitative Chemical Constituents of *Hymenocardia acida* Timber

Chemical Constituents	Units	Results
Lignins	%	23.0
Hemicellulose	%	28.0
Cellulose	%	46.0
Crude Fibre	%	0.9
Crude Protein	%	3.89
Carbohydrate	Mg/g	1.09
Phenol	Mg/g	1.94
Tannin	Mg/100g	860
Alkaloids	%	14.2
Flavonoids	%	8.2
Saponins	%	5.8
Oxalate	g/100g	1.0
Total Acidity	g/100cm^3	0.26
Cyanogenic Glycoside	Mg/100g	664
Lipid	%	5.6
Wood Charcoal	(g)	2.5
Pyroligneous acid	cm^3	2.75
Wood tar	cm^3	0.2
Wood gas	cm^3	841

Quantitative Chemical Constituents of *Hymenocardia acida* depicted that the sample contained 23% of lignin, 46% of cellulose, 28% of hemicelluloses and other parameters which help to confirm that the sample is a hard wood. Lignin is largely responsible for the strength, rigidity of plant and shields carbohydrate polymers from microbial and enzymatic attack. It contributes 20-25% of hardwood. Cellulose, a major chemical component of wood fibre wall, contributes 45-50% of hardwoods dry weight. Hemicellulose is a group of carbohydrate biopolymers that exist in close association with cellulose in the plant cell wall but it is less complex and easily hydrolysable (Arntzen, 1994; Desch and Dinwoodie 1996). The destructive distillation of *Hymenocardia acida* gave rise to four products in the following compositions; wood charcoal (2.5g), pyroligneous acid (2.75cm^3), wood tar (0.2cm^3) and wood gas (841 cm^3). As wood reaches elevated

temperatures, the different chemical components undergo the thermal degradation that affects the performance of wood. The extent of the changes depends on the temperature level and length of time exposed (White and Dietenberger, 2001). The thin layer chromatography of the chloroform and chloroform-methanol extracts showed three components with R_f values of 0.7, 0.6 and 0.5. The TLC results confirmed the presence of some components and its high purity.

Table 6: Thin layer chromatographic characteristics of *Hymenocardia acida*Timber extract.

Sample	Number of spot	Rf value
Chloroform-methanol extract.	2	0.6 & 0.5
Chloroform extract	1	0.7

Tables 7: Fourier Transformed Infrared and Ultraviolet spectra of Chloroform –methanol 1st spot extract.

Wave number (cm^{-1})	Suspected chromophores
3424.73	O-H stretch for alcohols, phenols and carboxylic acid
2856.67	C-H stretch for alkanes and aromatics
2099.59	C=N stretch for nitriles
1603.44	C = O stretch for ketones, carboxylic acid, amides & esters
1458.23	C=C stretch for alkene and aromatic rings
1106.21	C–O stretch for alcohols, esters and carboxylic acids
1017.48	C–H deformation bonds for alkyl groups
UV λ_{max} 218.50 and 285.50	Indicating highly conjugated aromatic amide..

Table 8: Fourier Transformed Infrared and Ultraviolet Spectra of Chloroform – methanol 2nd spot extract**.**

Wave number (cm^{-1})	Suspected chromophores
3402.54	O–H stretch for phenols and alcohols
2843.17	C–H stretch for alkanes
2520.08	C=N stretch for nitriles
2160.35	C=N stretch for nitrile
1653.05	C=O stretch for ketones, acid amides and esters
1422.55	C=C stretch for alkene and aromatics
1024.24	C–H deformation bonds for alkyl groups
UV λ_{max} 209.00 and 285.00	Indicating highly conjugated aromatic amide

Table 9: Fourier Transformed Infrared and Ultraviolet Spectra for *Hymenocardia acida* Chloroform extract.

Wave number (cm^{-1})	Suspected chromophores
3440.16	O – H stretch for alcohols and phenols
2983.95	C – H stretch for alkanes and aromatics
2504.65	C = N stretch for nitriles
2118.87	C = C stretch for alkenes
1647.26	C = O stretch for ketones, acid amides & esters
1416.76	C = C stretch for alkenes and aromatics
1104.28	C – O stretch for esters
940.33	C – H deformation bond for alkyl and methyl groups
UV λ_{max} 279.50 and 658.50	Indicating highly conjugated trisubstituted aromatic compound.

From the FTIR and UV spectra of the isolated compounds, the bands observed are summarized in Tables 7-9. The O-H stretching bands at 3440.16cm^{-1}, 3424.73$cm^{-1}$and 3402.54cm^{-1} are of alcohols, carboxylic acid and phenols The O-H can be said to be associated. The C-H stretching at 2983.95cm^{-1}, 2856.67cm^{-1}, and 2843.17cm^{-1} corresponds to that of an aliphatic C-H. The C=N absorption peak for nitriles appeared at 2504.65cm^{-1}, 2099.59cm^{-1} and 2160.35cm^{-1}. The C=O stretching bands at 1603.44cm^{-1}, 1647.26cm^{-1} and 1653.05cm^{-1} are that of ketones, acid amides, esters and carboxylic acids. The C-O absorption peak for alcohols, esters and carboxylic acids appeared at 1106.21cm^{-1} and 1104.28cm^{-1} while the C-H deformation bonds for alkyl groups occurred at 940.33cm^{-1},1017.48cm^{-1} and 1024.24cm^{-1}. The absorption in the ultraviolet visible spectra and FTIR spectra suggested that the active compound might be 1, 2,3-trisubstituted aromatic compound with O-H, C=O, and C=N groups attached.

Conclusion: The results of thermal and variable characteristics, phytochemical and AAS analysis of the timber, *Hymenocardia acida* had shown that it contained some components that could made it useful in animal feed formulation and as well a good material for various construction works. The UV and FTIR spectra showed that it contains some bioactive compounds. The presence of many secondary metabolites showed that *Hymenocardia acida* could be used in the cure and management of various diseases. Moreover, the complex chemical makeup of the timber showed the presence of cellulose,

hemicelluloses, lignin and other components in the right proportion which confirmed that *Hymenocardia acida* is a fire resistant hardwood that could be very effective in various construction works.

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