A Comparative Study Between Ignition Time (IT) And Oven Dry Density (ODD) As Fire Characteristics Of Some Tropical Timbers

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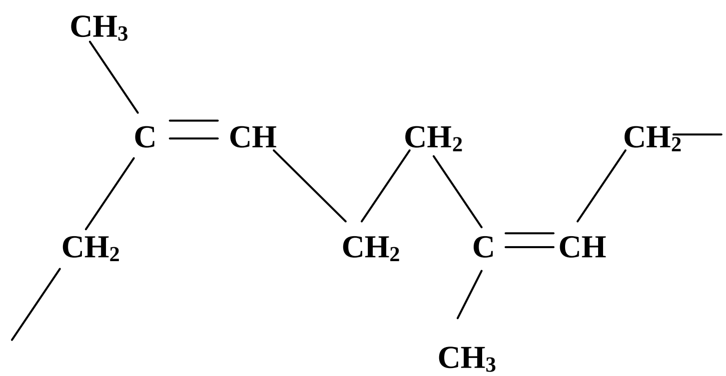
Abstract. Timber is an essential raw material needed of construction in building industry and serves as source of energy in some homes. In this research, fire characteristics of fifty-seven (57) tropical timbers were investigated. The characteristics studied are: ignition time, and oven dry density. The tropical timbers with the highest **IT** and **ODD** are ***G. gnetoides*** and ***Manilkara*** respectively while the ones with the least of these fire characteristics were ***M. indica*** (variety-German mango) and ***B. bonopozense*** respectively. Although greater majority of tropical timbers with lower ODDs possess lower ignition time, greater majority of the timbers with higher ODDs possess higher ignition time, this suggests that there is direct relationship between the ignition time of the tropical timbers and their oven dry densities. Though density is an important factor in determining the fire characteristics of timber, the cellular structure, molecular composition, orientation of fiber and timber extractives (eg resins) deserve a special attention in ultimate result. In this work , identification of the timbers that are fire resistant and otherwise are compared with respect to ignition time of these tropical timbers with their oven dry densities.

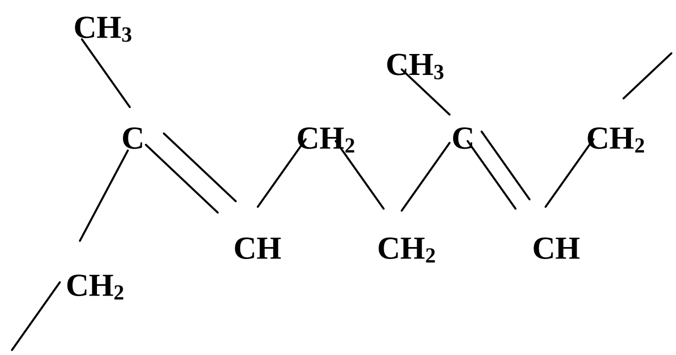
Keywords: Tropical timbers,ignition time, oven dry densities, fire characteristics, fire resistant and non-fire resistant timbers.

INTRODUCTION:

A tree is a large woody plant with a main stem (trunk) which does not usually branch until several feet from the ground. Trees are perennials and are taller than shrubs. The size of a tree depends on the climate and the type of soil (Stone *et al*., 1991). Many bioactive compounds are derived from trees. These include those compounds that are of biological, industrial, commercial, agricultural and domestic importance had been derived from trees (plants). Indeed, trees are beneficial to man by providing some useful agricultural produce such as rubber, cocoa used for production of stimulants and timbers for construction of buildings for habitation. ***Hevea brasiliensis*** is a native of the Amazon Region of Brazil but it is nowadays grown in plantations in different parts of the world, e.g. Nigeria, Sri Lanka and Malaysia. Natural rubber is a type of hydrocarbon known as a polyterpene, $(C_5H_8)n$, and exists in two isomeric forms.



Cis Poly (2-methylbuta-1,3-diene)
Cis –Polyisoprene
Elastic form



trans - Poly (2-methylbuta-1, 3-diene) (Tewari *et al.*,1980)
trans – Polyisoprene
nonelastic form

(laminations) which are glued together with the grain of each at right angles to its neighbour and then placed in a press. A variety of timbers is used in making plywood.

Also,trees are of paramount importance worldwide because they are both biologically and economically important to man. Biologically, plants (trees) and animals (including man) live an interdependent life. This can be seen in the area of: (i) Taking in of carbon (IV) oxide and giving out oxygen, (ii) Synthesis of food, (iii) Animals die and decay to form plant food (manure) (www.google.com, www.mamma.com. 2007).

$$6CO_2 + 6H_2O + Energy \longrightarrow C_6H_{12}O_6 + 6O_2$$

Trees are indispensable sources of both coarse and fine fibres used in the manufacture of cloths or garments.

Camphor is obtained from the wood and leaf of ***Cinnamomum camphora***, a tall tree of China, Japan and Taiwan origin. It has a characteristic strong but agreeable odour and is widely used in very small quantities in perfumery and medicines (Fina, 1977). Cinnamon is the dried brown bark peeled off from ***Cinnamomum zeylanicum,*** a small tree of Ceylon. It is aromatic and tastes sweet. It is extensively used for flavouring foods and vegetables. Cinnamon oil is extracted from the bark and leaf of ***cinnanomum*** tree. It is used in combination with some drugs as an intestinal antiseptic (Dutta A.C. (1981).

Sample collection and preparation: The fifty-seven (57) tree species samples were collected from eleven states in Nigeria. The states are: Anambra, Imo, Enugu, Sokoto, Katsina, Kano, Kebbi, Yobe, Edo, Zamfara and Gombe. The map showing the states in Nigeria are shown in **Fig.1**.

Fig.1 Map showing the thirty-six (36) states in Nigeria

Some of the tree species were living trees cut down while others Some were already felled trees. Dulmer machine was used to cut out part of the tree drunk. Thirty-two timbers species were obtained from the saw mills at Onitsha, Nnewi and Awka in Anambra State. The tree

species were authenticated by the Forest Officer in each of the States The saw millers were able to identify the botanical names of some timbers collected from the timber mills. By mentioning the local or common name of tree species and by examining the parts of tree species, the Forest Officers were able to identify the botanical names of the timber species.
After the collection and authentification, they were occasionally conveyed to the saw mill where each timber was cut into two different shapes and sizes; That includes:
(i) Splints of dimensions of 30cm x 2.5cm x 0.6cm
(ii) Cubes of dimensions of 2.5cm x2.5cm x2.5cm . The splints of timber were dried in an oven at 105^0C for 48hours before the experiment. American Standard for Testing and Materials (ASTM) was employed in the analysis. The picture of the saw mill used is in **Figure 2**.

Fig.2 Photograph of saw mill at Ihiala

Determination of Ignition Time (IT) of the timbers:
Three oven dry splints of each tree specie were clamped vertically, cigarette lighter was brought very close to each splint till it nearly touches the splint. The cigarette lighter was adjusted to give steady flame. The time taken by each splint to catch fire was recorded. The average time taken by the three splints of timber to catch fire was calculated and recorded as the ignition time. The results obtained were used to draw Table and a bar chart. The bar chart shows the Ignition time of these Tropical timbers;

Determination of Oven Dry Density (ODD):
Three 2.5cm cubes of each timber were randomly selected from one hundred and eighty cubes of the tree species. Each was weighed with Top loading balance, Model: PL 203, Make: Mettler Toledo. After recording the initial weight, the sample was transferred into the drying

oven at the temperature of 105°C. The sample was left in the oven for three hours. After the heating, the oven was switched off, and the sample left overnight to cool. The sample was re-weighed after twelve hours. Care was taken to ensure that sample did not absorb moisture before and during weighing. After recording the second weight for each, the samples were taken back into the oven for another 3hours at that same temperature. This was repeated until any two subsequent weights were equal i.e. constant weight attained. Three cubes of each tree specie were tied together with a copper wire and weighed as a single entity. Cu wire was removed and the three samples re-weighed. The weight of a cube was obtained by calculating the average of the three samples of each tree specie. The dimensions of the three 2.5cm cubes were measured and the volume of each was calculated. The average volume of the three samples was recorded as the volume of each samples of the timbers. Finally the oven dry density of each tree species was determined by dividing the average dry weight of the three samples by the average volume of three samples.

$$\text{ODD} = \frac{\text{Average dry wt of samples } g/dm^3}{\text{Average volume of samples}}$$

Results and Discussion

The results of the investigations carried out in this work are given in **Tables 1 and 2, and Figures I and 2 .**

Discussion:

The thermal characteristics of tropical timbers investigated in this research include; ignition time **(IT)** and oven dry density **(ODD)** .

Table 1: Names of the selected fifty-seven (57) tropical timbers from Nigeria

Tree species No	Botanical name	Common name	Vernacular names
1.	*Cola nitida*	Colanut	Ibo - oji, Hausa – goro Yoruba - obi gbanja, Nupe – Chigban'bi
2.	*Newboldia levis*		Ibo – Ogilisi, Hausa – aduruku, Yoruba – akoko,Benin – Ikhimi
3.	*Crysophyllum albidium*	White Star apple	Ibo – udala Yoruba-Agbalumo,Edo-Otien
4.	*Treculia africana*	African bread fruit	Ibo – ukwa
5.	*Psidium guajava*	Guava	**Ibo – gova**
6.	*Citrus sinensis*	Sweet orange	Ibo – oloma
7.	*Dacroydes edulis*	Native pear	Ibo – ube
8.	*Chlorophoro exelsa*	Iroko	Ibo – orji, Hausa – loko, Yoruba – iroko, Benin – uloko Nupe – rook,Ijwa – olokpata
9.	*Gaeis guineensis*	Oil palm tree	Ibo – nkwu
10.	*Cocus nucifera*	Coconut tree	Ibo – aku oyibo
11.	*Persea Americana*	Avocado pear	Ibo – ube oyibo

12.	*Irvingia smithii*		Ibo – ogbono
13.	*Irvingia gabanensis*		Ibo – ugiri, Yoruba – Oro, Benin – Ogwe, Efik – Oyo Nupe – pekpeara,Ijaw – ogboin
14.	*Caesalpina pulcherima*	Pride of Barbadose	
15.	*Terminalia catappa*	Umbrella tree or Indian Almond	
16.	*Spathodea campanulala*		Ibo – echichii
17.	*Ricinovenvron heudenocii*		Ibo – okwe
18.	*Ficu natalensis*		Ibo – ogbu
19.	*Banbax bonopozense*		Ibo – Akpu ,Yoruba – Puopola,Benin – oboidia Ijaw – idoundu
20.	*Ceiba petandra*	Silk cotton plant	Ibo – akpu ogwu,Yoruba – araba,Benin – okha, Efik – ukem Ijaw – afalafase
21.	*Cola gigantia*		Ibo – ebenebe, Hausa – bokoko, Yorubo – ogugu, Benin – ukpokpo, Efik – dikir, Ishan – abolo
22.	*Acacia nilotica*	Cacia	Hausa – bagaruwa, Kanuri – kangari,Fulani – gaudi
23.	*Nauclea diderrichii*		Ibo – uburu mmiri, Yoruba – opepe, Benin – obiakhe, Ijaw – owoso,Urhobo – urherekor
24.	*Gmelina arborea*	Bushbeech or Meligna	Ibo – malina,
25.	*Pteracarpus soyauxi*		Ibo – oha
26.	*Annoa senegalensis*		Ibo – oghulu, uburu ocha, Yoruba – abo,Hausa – Swandar daji,
27.	*Canarium schwanfurthii*		Ibo – ube okpoko
28.	*Pinus carribean*	Whispering pine	
29.	*Albizia ferruginea*	Albizia	Ibo- Ngwu or ngu Yoruba – Ayinre oga, Benin – uwowe
30.	*Brachystegia nigeria*		Ibo – ufi, Yoruba – akolodo,Benin – okwen, Ishan – eku Ijaw – akpakpa, Efik – ukung,Boki – kpeunik, Ekoi – etare
31.	*Dialuim guineensis*		Ibo – icheku
32.	*Napoliana vogelii*		Ibo – nkpodu
33.	*Accio bateri*		Ibo – araba
34.	*Brachystigia eurecomya*		Ibo – achi mkpuru,Yoruba – akolodo,Benin – okwen Ijaw – akpakpa,Ishan – eku,Ekoi – etare,

			Boki – kepuruk Efik – ukung
35.	*Pluneria africana*		
36.	*Walteria americana*		
37.	*Azadirachta indica*	Neem plant	Hausa – dogonyaro
38.	*Khaya senegalensis*	Mahogany	Hausa – madacu
39.	*Manilkara*		Ibo – ukpi
40.	*Alstonia congensis*		Ibo – egbu
41.	*Tectona grandis*	Teak	
42.	*Mansonia altissima*	Mansonia Iron tree	Yoruba-ofun
43.	*Isoberlinia tomentosa*	Berlinia	Ibo – uboba, Hausa – faradoka (white doka) Nupe – baba
44.	*Isoberlinia doka*	Berlinia	Ibo – ububra ibu, Hausa – doka Nupe – babarochii bokun, Tiv – mkovol
45.	*Garcinia kola*	Bitter kola	Ibo – ugolo/adi, Yoruba – orogbo Benin –edun, Efik – efiari, Ijaw – okan Ibibio – efiat
46.	*Garcinia gnetoides*	Wild ugolo	Ibo – ugolo agho
47.	*Baphia nitida*		Ibo – aboshi ojii, Yoruba – irosun,Benin – otun, Efik – ubara Ijaw – abodi, Itsekiri – orosun, Urhobo – arhua
48.	*Baphia gracilipes*		Ibo – aboshi ocha
49.	*Terminalia brownie*	Congo afara	Ibo – edo, Hausa – baushe,Yoruba – idiodan
50.	*Terminalia superba*	Akmond tree (white afara)	Ibo – edo, Yoruba – afara,Benin – egboin nofua, Efik – afia eto,Ijaw – gbarada, Nupe –eji,Urhobo – unwonron
51.	*Terminalia glaucescens*	Black afara	Ibo –edo, Hausa – baushe,Yoruba – idiodan
52.	*Mangifera callina*	Kerosene mango	
53.	*Mangifera banganpalli*	Ordinary mango	Ibo – mango nkiti
54.	*Mangifera indica*	Mango with fibre	Ibo – opiolo mango
55.	*Mangifera indica*	Gernan mango	
56.	*Pentaclethra macrophyllum*	Oil bean tree	Ibo – ukpaka
57.	*Nauclea popeguinii*		Yoruba – opepe

Table 2: Ignition time and ODD of fifty-seven (57) tropical timbers.

Tree species No	Botanical name	IG Ignition Time x 10^0 Sec	ODD Oven dry density x 10^{-2} g/cm^3
1.	*Cola nitida*	10.5	66.6
2.	*Newboldia levis*	37	68.1
3.	*Crysophyllum albidium*	36	62.7
4.	*Treculia africana*	25	58.8
5.	*Psidium guajava*	48	**85.5**
6.	*Citrus sinensis*	79	86.5
7	*Dacroydes edulis*	28	51.1
8.	*Chlorophoro exelsa*	27	58.4
9.	*Gaeis guineensis*	12	59.9
10.	*Cocus nucifera*	25	60.1
11.	*Persea Americana*	26	43.4
12.	*Irvingia smithii*	54	81.7
13.	*Irvingia gabanensis*	36	87.8
14.	*Caesalpina pulcherima*	16	46.5
15.	*Terminalia catappa*	38	65.4
16.	*Spathodea campanulala*	18	32.0
17.	*Ricinovenvron heudenocii*	19	34.2
18.	*Ficu natalensis*	24	48.5
19.	*Banbax bonopozense*	19	24.0
20.	*Ceiba petandra*	35	35.5
21.	*Cola gigantia*	72	54.0
22.	*Acacia nilotica*	36	64.6
23.	*Nauclea diderrichii*	45	54.1
24.	*Gmelina arborea*	26	58.6
25.	*Pteracarpus soyauxi*	24	47,5
26.	*Annoa senegalensis*	52	37.0
27.	*Canarium schwanfurthii*	34	41.3
28.	*Pinus carribean*	11	40.7
29.	*Albizia ferruginea*	32	66.8
30.	*Brachystegia nigeria*	61	72.1
31.	*Dialuim guineensis*	30	73.1
32.	*Napoliana vogelii*	108	74.3
33.	*Accio bateri*	100	97.5
34.	*Brachystigia eurecomya*	95	77.2
35.	*Pluneria africana*	61	60.3
36.	*Walteria americana*	22	50.1
37.	*Azadirachta indica*	60	79.0
38.	*Khaya senegalensis*	39	77.5
39.	*Manilkara*	93	109.7
40.	*Alstonia congensis*	23	40.1

41.	*Tectona grandis*	22	55.1
42.	*Mansonia altissima*	44	59.6
43.	*Isoberlinia tomentosa*	12	49.6
44.	*Isoberlinia doka*	64	45.1
45.	*Garcinia kola*	70	92.1
46.	*Garcinia gnetoides*	112	68.3
47.	*Baphia nitida*	75	88.6
48.	*Baphia gracilipes*	41	79.2
49.	*Terminalia brownie*	43	69.3
50.	*Terminalia superba*	50	55.6
51.	*Terminalia glaucescens*	19	56.2
52.	*Mangifera callina*	28	60.9
53.	*Mangifera banganpalli*	34	65.3
54.	*Mangifera indica*	52	74.8
55.	*Mangifera indica*	06	44.4
56.	*Pentaclethra macrophyllum*	66	78.8
57.	*Nauclea popeguinii*	42	63.2

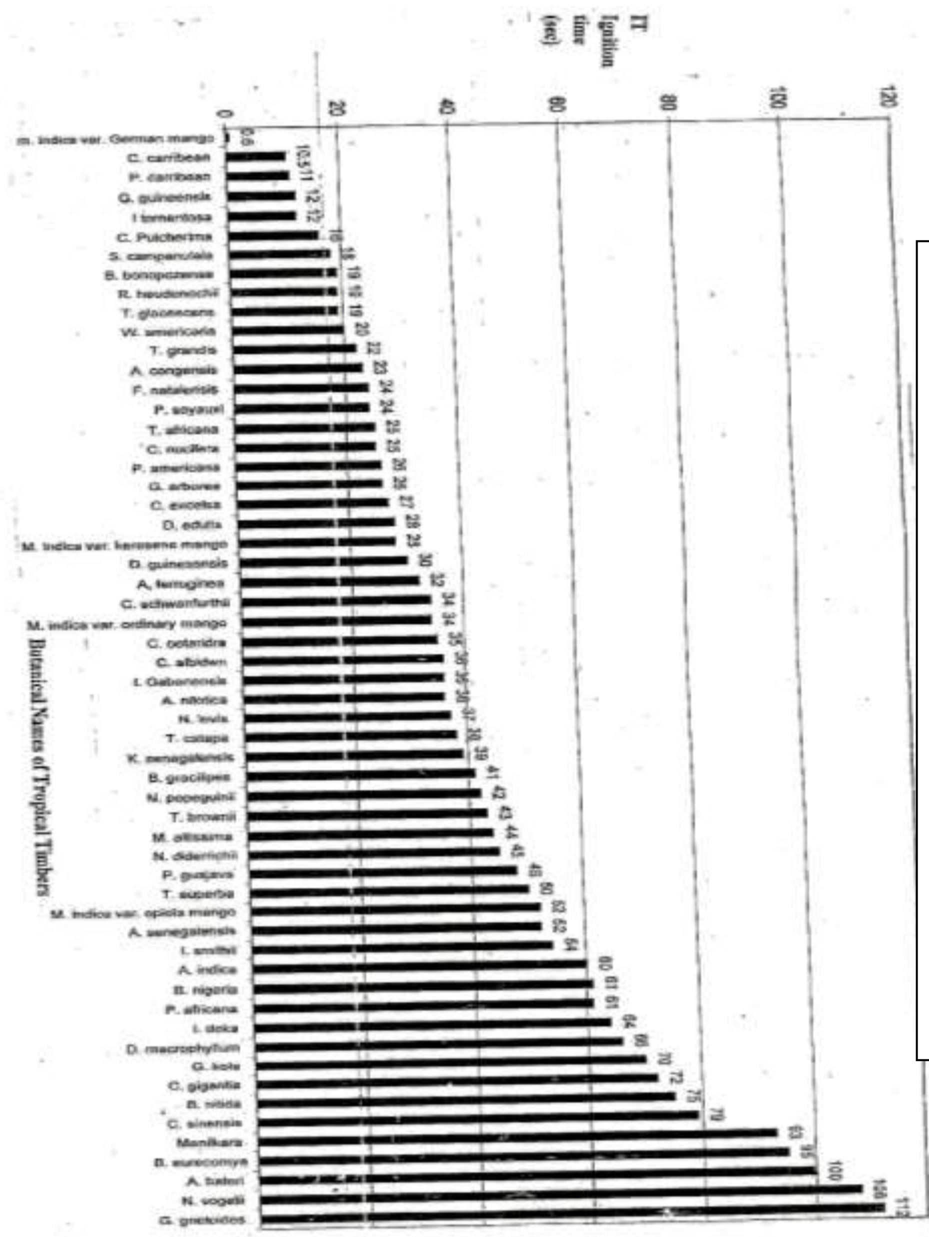


Fig.3. Gragh of ignition time (IT) of the 57 tropical timbers

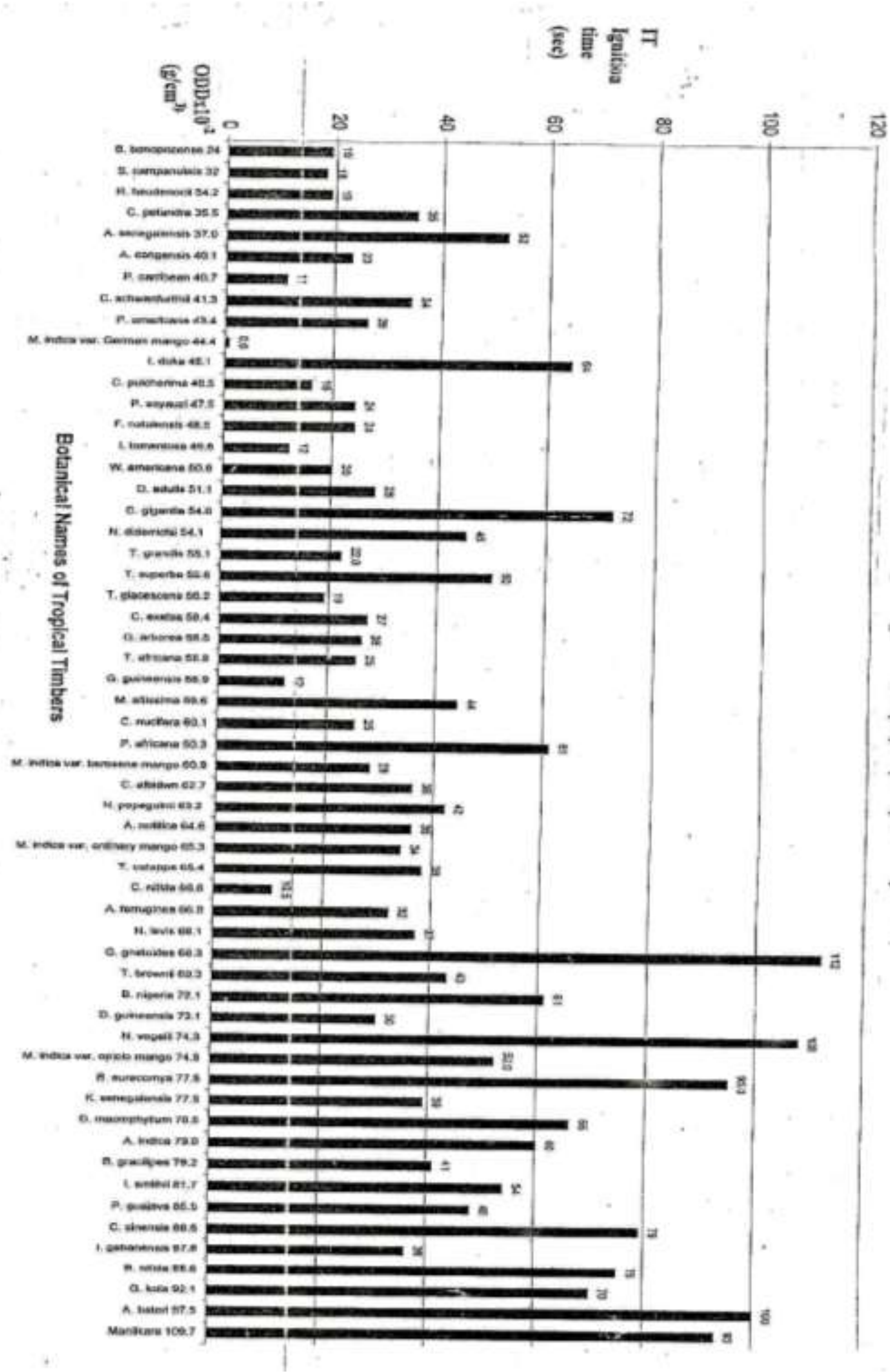


Fig.4. Graph of ignition time vs (ODD) Oven dry density

Fig. 3 shows the bar chart of ignition time of fifty-seven tropical timbers. The ignition time of these fifty- seven tropical timbers were represented in their increasing or ascending order of magnitude. It is easily seen that ***M. indica (German mango)*** has the least ignition time while ***G. gnetoides*** has the highest ignition time. The Figure also shows that many of these timbers have about the same ignition time. Those with equal ignition time are; ***G. guineensis and I. tomentosa(12 sec), B. bonopozence, R. heudenochii and T. glacescens (19 sec); T. Africana***

and C. nucifera (25 sec; D. edulis and a variety of ***M. indica-kerosene mango*** **(28 sec);** ***C.schwanfurthii and M. indica var. ordinary mango(34 sec);I.gabanensis,C. albidium and A.nilotica(36 sec);M.indica var. opiolo mango and A.senegalensis(52 sec)and B.nigeria and P.africana(61 sec).***

Fig. 4 is the graph of Ignition time vs Oven Dry Density. A good number of these timbers with high **ODD** values also have high ignition times while most of those with lower **ODD** values have correspondingly lower ignition times. Nonetheless, it is observed that the timber with the least **ODD** does not possess the least ignition time and the one with the highest **ODD** does not possess the highest. Furthermore, some timbers that possess equal ignition times were found to have varied **ODDs**. Generally speaking, it is clear that ignition time increases gradually with increasing **ODD**. This apparently means that the denser the wood, the longer the time it takes to ignite. Since greater majority of the tropical timbers with lower ODDs possess lower ignition time and greater majority of the timbers with higher ODDs possess higher ignition time, we can say that our observation is in order. In order words, there is direct relationship between the ignition time of the tropical timbers and their oven dry densities. This implies that as the ODDs of the tropical timbers increases, their ignition time or the length of time it will take the timbers to catch fire also increases in the same direction. The density of wood is essentially due to the arrangement or orientation of the macromolecules, fibrils and the fibers as well as the cementing materials. It is also due to the orientation and compact nature of the arrangement of their cell wall. There is very little or no air- spaces in-between the grains (arrangement of fibers) in the case of very dense woods. Light wood has a lot of pores or air-spaces in-between the grains. According to ***Panshin et al, dense heavy woods are more resistant to ignition than highly resinous soft woods(Panshin et al.,1980)*** **.** Apart from these organic aspects, it is common knowledge that wood often contains some metals in forms of carbonates, silicates etc. Thus, it is clear that wood is such a complex material that to explain some of its gross characteristics down to molecular level could, be rather intriguing. Ignition of a material usually follows the sequence-heat source touches a small part temperature of the small area is raised, amplitude of molecular vibration is increased to a point of bond scission\eruption, pyrolysis starts followed by gasification. The issuing hot pyrolysates meets oxygen. The onset of exothermic oxidation of the pyrolysis products is ignition. Thus ignition should depend on the quantity of materials in the substance, as well as their arrangements.

CONCLUSION

Ignition time of timbers should be put into consideration for one to make wise choice of timber. There is direct relationship between the ignition time of the tropical timbers and their oven dry densities.

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