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Suitability of chemically treated woods in the design and fabrication of cylindrical barrel flange for the 50 tons injection molding machine

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Abstract
Studies was carried out to design and fabricate wood based cylindrical flange samples for the 50 tons injection molding machine from the wood fibre sample with the least lignin and hemicellulose percentage composition after alkali (NaOH) treatment. The untreated Obeche, Mahogany and Oak samples had mean compositions of 34.10±0.87, 36.10 ±3.14 and 35.10±1.42% respectively for the hemicellulose and 30.20 ±1.22, 32.30±2.02 and 33.20±1.55% respectively for the lignin. The NaOH treated Obeche, Mahogany and Oak samples had mean compositions of 28.10±0.53, 18.22±0.31 and 25, 31±2.41% respectively for the hemicellulose and 26.30±1.44, 12.60±0.97 and 23.20±1.83% for the lignin. After the selection of the treated Mahogany wood samples, the produced Mahogany based cylindrical flange had 40.14±1.74, 75.07±3.02, 25.00±2.89, 55.19±1.88 and 63,22 ±3.42 MPA as mean values for impact strength, tensile strength, hardness, brittleness and flexural strength respectively. With the obtained values of the tested mechanical properties of the produced Mahogany based cylindrical based flange, the 50 tons injection molding can be operated efficiently to sustain production processes for as long as possible without failures from the flange position.

Keywords: Chemical treatment, mahogany hard wood, cylindrical flange, efficient machining and mechanical properties

Introduction
Biomass is a collective term used for all materials that are biogenic in origin, i.e derived from the product of photosynthesis. Natural fibres are produced from renewable resource materials and are biodegradable and relatively inexpensive compared to synthetic fibrous materials in their application in industrial fabrications. In today's industrialization, with limited resource availability and increase in resource demand, it is more and more necessary to explore and popularize practical green and sustainable environmentally friendly materials in wood, as an engineering tool for use in the industries to engender production processes.
Most agricultural wastes consist of cellulose, hemicellulose, lignin and other materials called extractives (Aberuagba, 1997) [1]. Mohanty *et al.*, (2000) [6] reported that the mechanical properties of wood fibres are seriously hindered by considerably high composition of lignin and hemicelluloses. Dhanalaskshimi *et al.*, (2015) [3] stated that the hydrophilic nature of the untreated walnut fiber and the hydrophobic nature of PET matrix which resulted in inappropriate and poor interfacial bonding between them could have been responsible for the low impact strength of the untreated fiber reinforced PET composites. Mbah *et al*., (2020) [5] reported that flexural, impact and tensile properties of wood based engineering materials are of great importance for any structural material and composites development and use, hence the treatment of wood or natural fibres. Sahn and Cha, (2018) [9] observed that the chemical treatment of wood or lignocellulosic materials, improve its tensile, flexural and impact strength to be able to serve any engineering purpose. According to Mbah *et al*., (2020) [5], the acid, alkali, formaldehyde and heat treatments are commonly employed on woods to remove lignins and hemicellulose and hence improve its mechanical properties for industrial applications. Flanges defined as machine parts that connect pipes to valves, fittings strawers and pressure valves; are usually important in sustaining the efficiency of machine operation in any industrial process. Failures of the flange in machines due to stress and prolong use can hinder or stop production processes. Rowell, (2004) [8] stated that adequate treatment of wood fibres improve its mechanical properties to be able to replace conventional mild steel

based machine parts in order to support or sustain the efficiency of machine operation in the industry. Obeche, oak and mahogany wood fibers have considerable lignin and hemi-cellulose composition that require treatment to enhance their mechanical properties for engineering applications. Good response of wood fibres to chemical treatments increase its suitability for use as a replacement for mild steel based material in the fabrication of the cylindrical flange to support the operational efficiency of the 50 ton injection molding machine, hence this research.

Materials and Methods

Sample collection

Mahogany, oak and obeche wood fibres were procured from the Wood section in Scientific Equipment Development Institute, Akwuke, Enugu.

Sample preparation

The wood samples were each cut into six (6) pieces using band saw and machined into their desired dimensions of 180mm X 90mm respectively using Lathe Machine.

Alkali treatment

Three (3) pieces of the wood samples were each soaked in 1M NaOH for 180 min. Subsequently, the samples were sun dried for 24hr.

Lignin and hemicellulose determination

The percentage composition of the lignin and hemicellulose in both the treated and untreated wood (mahogany, oak and obeche) samples were determined using the methods described by (Xie *et al*., 2013) [11].

Machining of the selected, treated mahogany wood samples.

Based on the considerably low lignin and hemi-cellulose composition of the mahogany wood samples under the alkali treatment, they were selected for machining for the fabrication of the cylindrical flange. Wood machining is associated with the removal of material with moderate forces, minimal tool friction, and a good surface finish. In calculating the machinability index of the machined sample, the following formula was applied to achieve that:

The formula of the Machinability Index

$$MI\ (\%) = (Vi/Vs) \times 100$$

Where,

MI=Machinability Index.

Vi = The cutting speed of the metal for 1-minute tool life.

Vs = The cutting speed of standard free cutting steel for 1-minute tool life

Determination of the mechanical properties of the treated mahogany based cylindrical flange samples

The fabricated mahogany based flange samples for the 50 tons injection molding machine were subjected to impact strength, tensile strength, hardness, brittleness and flexural strength determination as described by (Xie *et al*., 2013) [11].

The Machining Processes in the production of the cylindrical flange samples

Step Turning: Step turning creates two surfaces with an abrupt change in diameters between them. The final feature resembles a step.

Facing

Facing is an operation of machining the end of a workpiece that is perpendicular to the rotating axis. During the facing, the tool moves along the radius of the workpiece to produce the desired part length and a smooth face surface by removing a thin layer of material.

Parting

Parting is a machining operation that results in a part cut-off at the end of the machining cycle. The process uses a tool with a specific shape to enter the workpiece perpendicular to the rotating axis and make a progressive cut while the workpiece rotates. After the edge of the cutting tool reaches the centre of the workpiece and it drops off. A part catcher is often used to catch the removed part.

Drilling

Drilling operation removes the material from the inside of a workpiece. The result of drilling is a hole with a diameter equal to the size of the utilized drill bit. Drill bits are usually positioned either on a tailstock or a lathe tool holder.

Boring

In boring operation, a tool enters the workpiece axially and removes material along the internal surface to either create different shapes or to enlarge an existing hole.

Lathes are capable of machining pieces with sophisticated features. The final part features of the cylindrical flange are produced by the utilization of various tools and by changing the kinematical relationship between the cutter and a work piece.

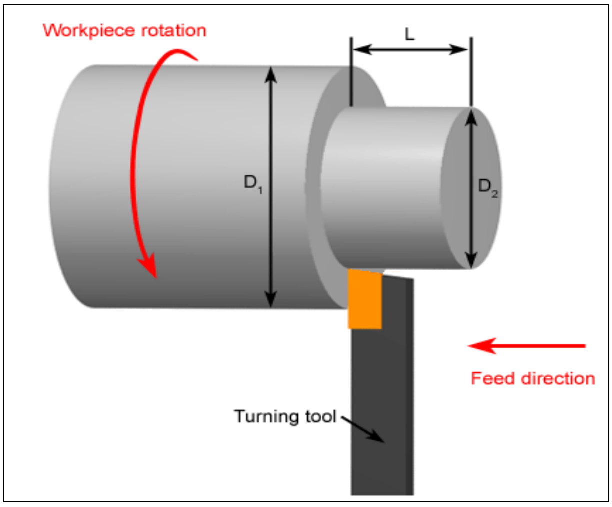

Fig 1: Workpiece step turning

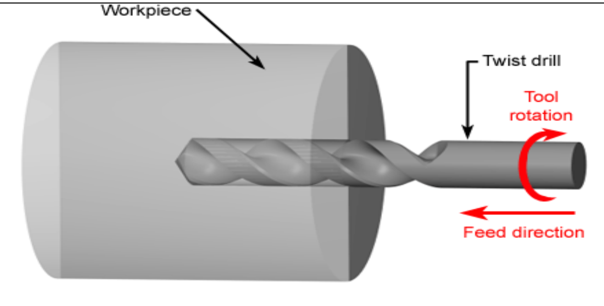

Fig 2: Workpiece boring

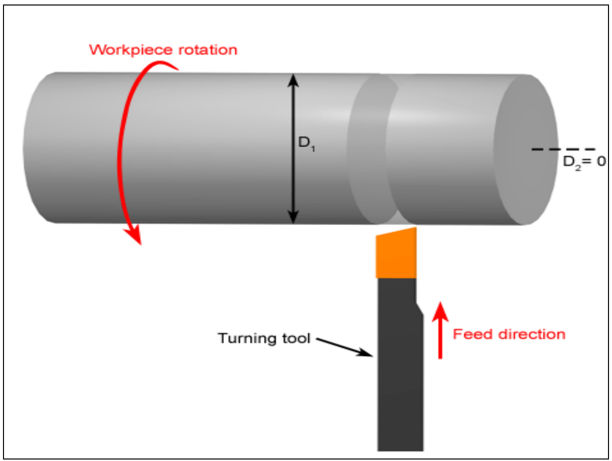

Fig 3: Workpiece parting

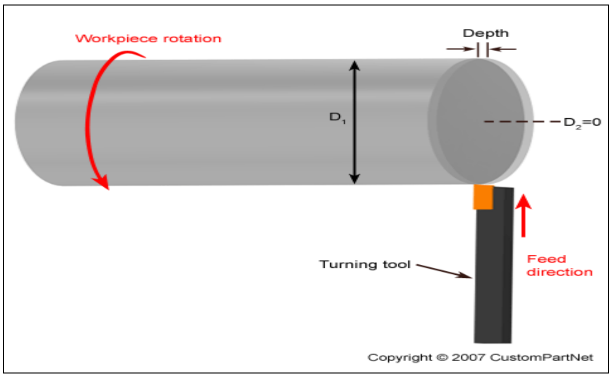

Fig 4: Workpiece facing

Fig 5: The damaged brass flange.

Fig 6: Machining of the wood flange

Fig 7: The produced mahogany based cylindrical flange

Results and Discussion

Table 1: Mean composition (%) of hemicellulose and lignin in the untreated wood samples**.**

% Chemical composition	Untreated Obeche sample	Untreated Mahogany sample	Untreated Oak sample
Hemicellulose	34.10±0.87	36.10±3.14	35.10±1.42
Lignin	30.20±1.22	32.30±2.02	33.20±1.55

Result of Table 1 shows that the mean hemicellulose composition in the untreated Obeche, Mahogany and Oak wood samples were 34.10±0.87, 36.10 ±3.14 and 35.10±1.42% respectively. The mean percentage hemicellulose composition in the untreated wood samples decreased in the following order; Mahogany > Oak > Obeche as shown in Figure 8. Also, 30.20 ±1.22, 32.30±2.02 and 33.20±1.55% were the mean lignin composition in the untreated Obeche, Mahogany and Oak wood samples respectively. The mean lignin percentage composition in the untreated wood samples decreased in the following order; Oak > Mahogany > Obeche as shown in Figure 8.

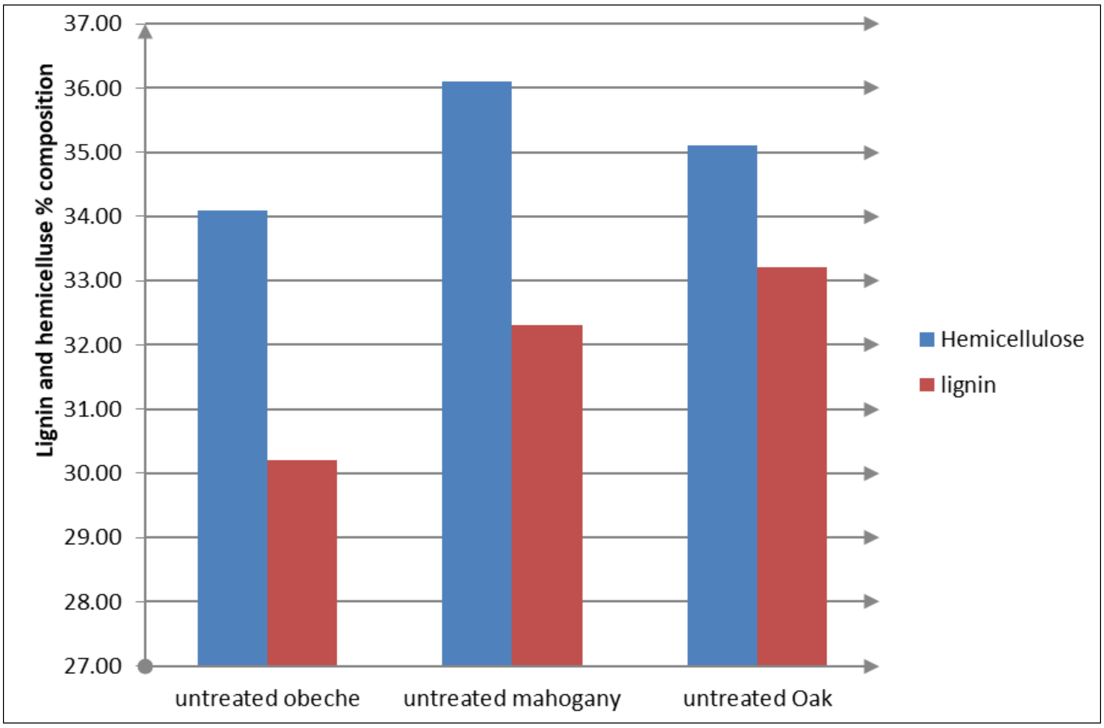

Fig 8: Bar chart representation of the mean composition (%) of hemicellulose and lignin in the untreated wood samples

Table 2: Mean composition (%) of hemicellulose and lignin in the NaOH treated wood samples**.**

% chemical composition	Treated Obeche samples	Treated Mahogany samples	Treated oak samples
Hemicellulose	28.10±0.53	18.22±0.31	25.23±2.41
Lignin	26.30±1.44	12.60±0.97	23.20±1.83

Result of Table 2 shows that the mean hemicellulose composition in the treated Obeche, Mahogany and Oak wood samples were 28.10±0.53, 18.22±0.31 and 25, 31±2.41% respectively. The mean hemicellulose percentage composition in the treated wood samples decreased in the following order; Obeche > Oak > Mahogany as shown in Figure 9. Equally, 26.30±1.44, 12.60±0.97 and 23.20±1.83% were the mean percentage composition of the lignin in the treated Obeche, Mahogany and Oak wood samples. The wood samples had mean lignin percentage composition in the following order; treated Obeche > treated Oak > treated Mahogany as shown in Figure 9.

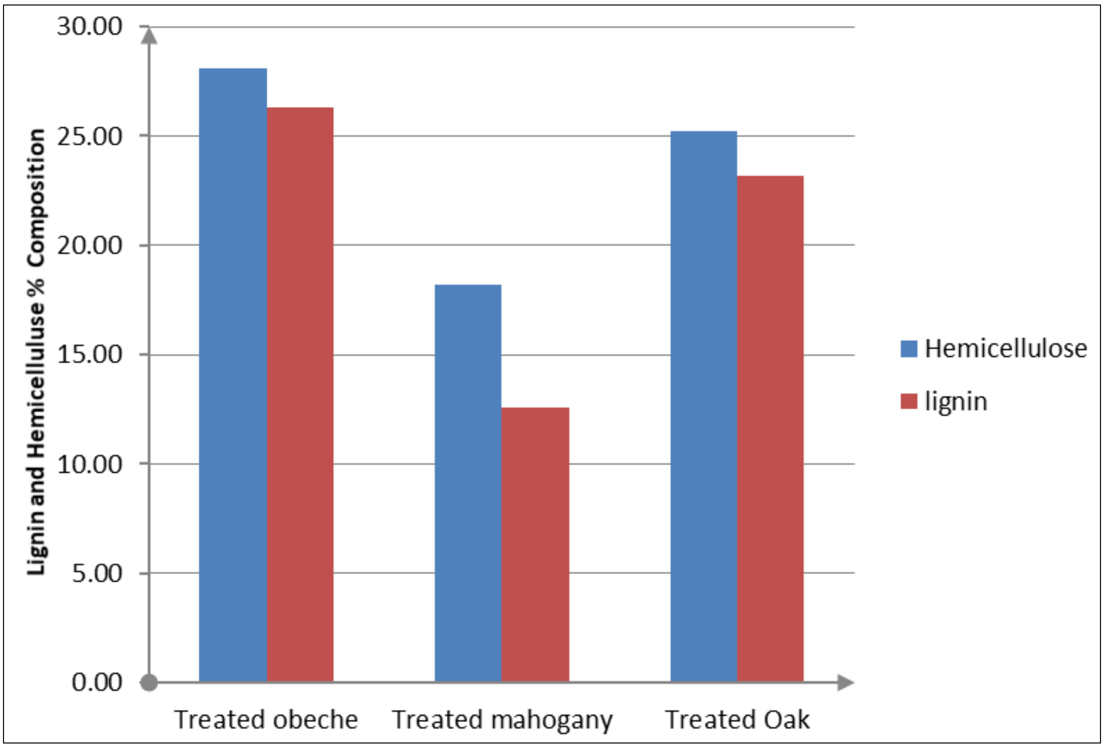

Fig 9: Bar chart representation of the mean composition (%) of hemicellulose and lignin in the treated wood samples

The result of Table 2 indicates that the alkali treatment of the wood samples considerably led to a decrease in their lignin and hemicellulose compositions compared to the result of the untreated wood samples in Table 1 and more importantly, the Mahogany wood samples had the most profound decrease in their lignin and hemicellulose composition compared to the other studied wood samples. Hence, it was this observation that informed the choice of the treated Mahogany wood samples in the design and fabrication of the wood based cylindrical flange samples for the 50 tons injection molding machine. According to Okeke *et al.*, (2018) [7], chemical treatment of wood results in changes in their cell wall chemistry occasioned by the extraction of lignin and hemicellulose that could decrease its mechanical properties during engineering application. Rowell, (2004) [8] equally observed that improvement in the dimensional ability and surface resistance to microbial attack and decrease in moisture sorption have been the motivation for research into the chemical modifications of wood. Similarly, Xie *et al.*, (2013) [11], stated that chemical treatment increases the dimensional stability of wood, protecting it from environmental damage such as degradation owing to weathering and microbial decay during service period. Mbah *et al.*, (2020) [5] reported mean values of 16.14±1.88 and 23.08±0.95% for lignin and hemicellulose respectively in the studied alkali treated walnut fibre samples, which compares favourably with the result obtained for the treated Mahogany wood samples. Okeke *et al.*, (2018) [7] obtained a higher mean value of 32.16±2.21% for lignin in the alkali treated breadfruit samples than what was reported in the treated Mahogany samples.

Table 3: Mechanical properties of the NaOH treated Mahogany based cylindrical flange samples

S/N	Mechanical properties tested	Mean value (MPA)
1	Impact strength	40.14 ±1.74
2	Tensile strength	75.07 ±3.02
3	Hardness	25.00 ±2.89
4	Brittleness	55.19 ±1.88
5	Flexural strength	63.22 ± 3.42

Result of Table 3 shows that the Mahogany based cylindrical flange samples had 40.14±1.74, 75.07±3.02, 25.00±2.89, 55.19±1.88 and 63,22 ±3.42 Mpa as mean values for impact strength, tensile strength, hardness, brittleness and flexural strength respectively. The determined mechanical properties of the flange smples had mean values in the following decreasing order; tensile strength> flexural strength > brittleness> impact strength > hardness as shown in Figure 10.

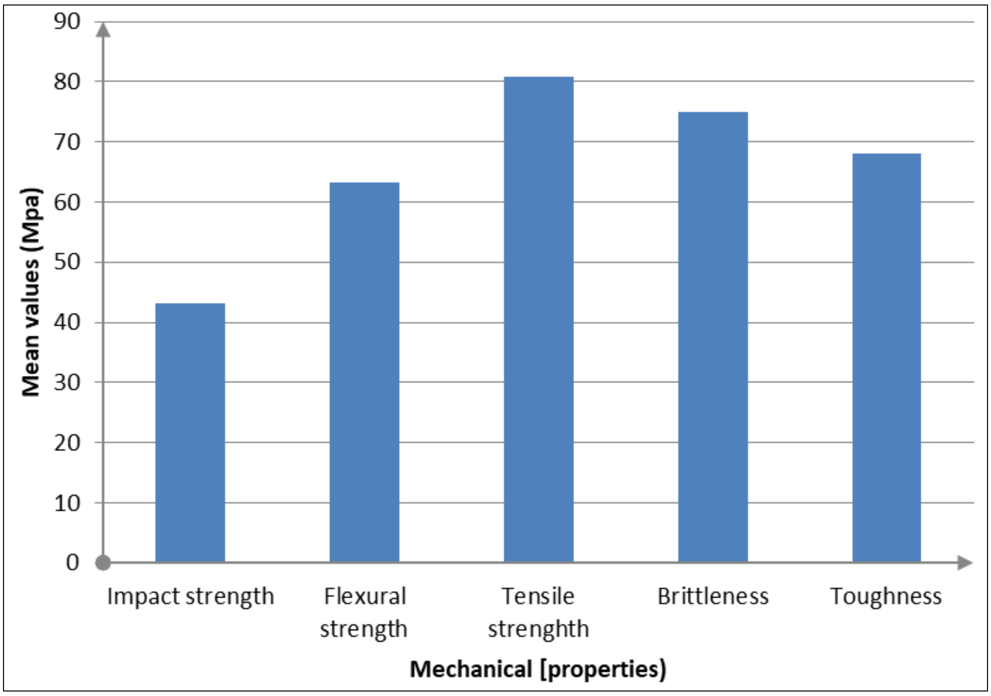

Fig 10: Bar chart representation of the mechanical properties of the NaOH treated Mahogany based cylindrical flange samples.

The mechanical properties of the wood based flange samples had values that falls within 40-200 Mpa stipulated by Anon, (1993a) [2], for materials ideal for the fabrication of machine parts for engineering application. The result of this study is consistent with the report of Vimod *et al.*, (2019) [10] that the tensile strength, flexural strength, toughness and elastic modulus of natural fibres increase after treatment because lignin and hemicellulose were removed.

Conclusion

The alkali (NaOH) treatment of the studied wood (Obeche, Mahogany and oak) samples significantly reduced their lignin and hemicellulose composition. The Mahogany samples had the least lignin and hemicellulose composition of the three studied wood samples after alkali treatment. Cylindrical flange samples were produced from the treated Mahogany wood samples and the determined mechanical properties makes it an ideal replacement for the conventional brass based cylindrical flange for the 50 tons injection molding machine. The produced Mahogany based cylindrical flange samples have since replaced the faulty brass cylindrical flange in aiding the smooth operational efficiency of the 50 tons injection molding machine.

Increased support by government and private individuals to advance research in the replacement of worn-out metallic parts of machines with wood fibres is necessary to decreasing the cost of machine maintenance, increasing the sanctity of the environment and strengthening the green technology initiative now on the front burner.

Conflicts of Interests

The authors' declare that there are no conflict of interests in carrying out this research and its publication.

References

1. Aberuagba F. The kinetics of acids hydrolysis of waste cellulose from maize cob and groundnut shells proceedings of the 27th annual conference of the NSCHE; c1997. p. 341-347.
2. Anon. Wood and metallic based panels- Determination of modulus of elasticity in bending strength. BSEN 310. British Standard Institute, 1993a. p. 81-84.
3. Dhanalaskihin IN, Kunakar N, Narute J. Effect of chemical treatment on the tensile strength of aruca reinforced natural rubber composites. Journal of Applied chemistry. 2015;14(5):567-579.
4. Ismail IM, Mahmood D, Hassan EB. Environmental effects on the degradation behavior of sisal fiber reinforced polypylene composites. Composite Sciences and Technology. 2002;34(5):1234-1244.
5. Mbah GO, Imoh UR, Omotioma M.and Onoh M. Effect of acetic acid on the mechanical properties of walnut fibre reinforced polyethylene terepthalate composite, International Research Journal of Modernization in Engineering Technology and Science. 2020;2(11):213-221.
6. Mohanty CB, Mohanty DN, Jadhav SA. Biofibers, biodegradable polymers and biocomposites an overview. Macromolecules and Material Engineering. 2000;7:676-690.
7. Okeke O, Ezeh E, Effiong I. Anya OU. Effect of chemical treatment and resin contents on the mechanical properties of breadfruit hull produced medium density particle boards. International Journal of Scientific & Engineering Research. 2018;8(4):851-858.
8. Rowell RM. Chemistry of solid wood. American Chemical Society in Chemistry Series, Washington DC. 2004;407;1135-1149.
9. Sahn JS. Cha SW. Effect of chemical treatment on the physical and mechanical properties wood fibres. Polymers. 2018;10(18);1391-1402.
10. Vimod A, Vijay R, Sngravelu D, Sanjay UR. Characterization of untreated and alkali treated fibres extracted from the stem of *Catharathus rosens*. Material Research Express. 2019;6:460-469.
11. Xie Y, Fu O, Wy Q, Xiao T, Millutz H. Effect of chemical modificationon the mechanical properties of wood. European Journal of Wood Production. 2013;71:401- 416.