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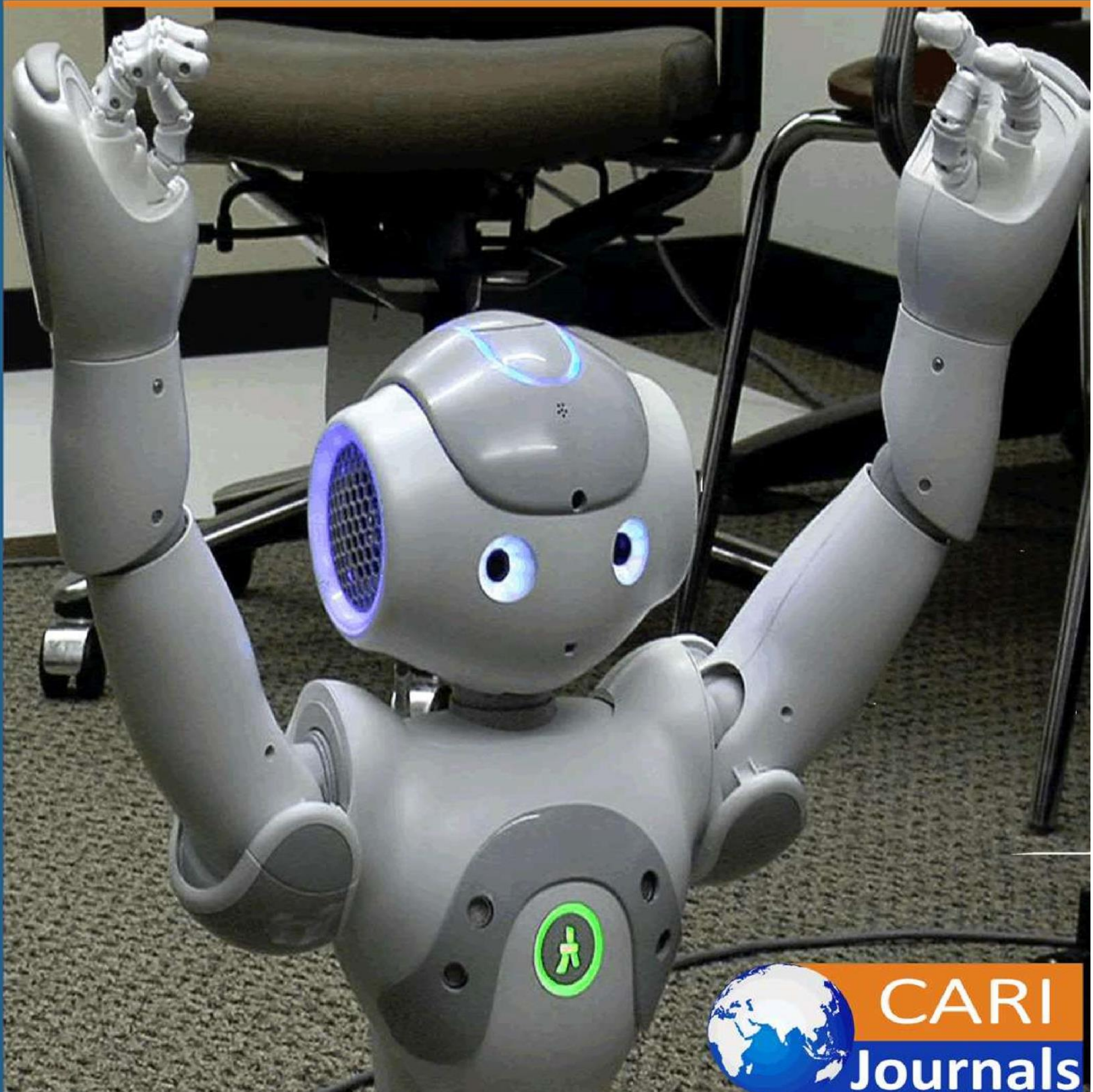

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Production of Wood-Plastic Composite from Mixed Particles of *Pterocarpus angolensis (*Mukwa) And *Gmelina arborea (*Roxb)

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Abstract

Purpose: It is increasingly difficulty to meet the demand and supply for solid wood for human difference end uses, in view of the alarming shrinkage of forest resource. But the un-ending in wood resource supply to wood-based industry basically continue to underscore the need to think beyond total dependent on solid wood. The study creates a template to ameliorate wood scarcity viz production of wood-plastic composite from mixed particles of *Pterocarpus* and *Gmelina*, further analysis the effect of particles size on the Physio–mechanical properties of composite.

Methodology: Five sieved size were employed, polyester and Meth ether Ketone peroxide (MEKP) were used as adhesive and accelerator respectively, sieved samples were oven dried under a control temperature of 102^0C to moisture content of 12 to 15%. Fabricated composite was machined according ASTM standards.

Findings: The water absorption of composite S_1, S_2, S_3 recorded higher water uptake compared to S_4 and S_5 composites. Experimental results of mechanical properties revealed progressive strength properties with sieved sizes, ranging from 23 KN/mm^2 to 67KN/mm^2 for compressive strength, while the tensile strength, ranged from 17KN/mm^2 to 30KN/mm^2. In addition, it was observed that, particle size has influence on the Physical and mechanical properties of composites.

Unique contribution to theory, practice, and policy: The study hereby concluded that chips from the above species can be used for the production of composite to ameliorate the demand of solid timber from our ecosystem.

Keyword: *Wood, Polyester, Composite, Physical and Mechanical Properties***.**

Introduction

Wood –plastic composites (WPCs) material have been dominant among all emerging materials because of its greater mechanical properties to weight ratio. The production of WPCs has been rapidly developed due its numerous advantages. One is the possibility of using recycled materials, both recycled polymers and wood, for its manufacturing; these create a template for green economic resulting in sustainable environment. The concept in natural fiber – reinforced composite materials is rapidly in use in terms of their industrial applications. Natural fiber composites could be 100% biodegradable; two, biological and environmental durability is cited often as a major advantage of natural fiber composites over other traditional structural materials. (WPCs) consumed wood component from the saw mill industry such as sawdust for manufacturing which is, the primary waste product of sawmills (Adefisan et.al. 2016; Richard et.al. 2000; Adefisan, and Adesope 2012; Liu and Zheng, 2021.Wood is an anisotropic in nature and is thus susceptible to cracking, deformation, warping due to dimensional instability from changes in ambient humidity. However, wood is susceptible to degradation caused by weather and biological factors, which restricts wood to specific exterior structural bearing application (Adefisan, et al, 2017; Emmanuel, et al 2021). It is increasing difficult to meet demand of human for wood supply for difference end uses in view of the alarming shrinkage in it supply, but the un-ending in wood-based industry continue to underscore the need to think beyond absolute dependence on round wood. Some studied have confirmed the effort by China to ameliorated wood scarcity via creation of suitable alternative materials from many renewable fibrous materials in their locality (Yashas, et. al, 2018; Richard et.al. 2000; Adefisan et.al. 2016). The mixing of wood fiber with thermoplastic polymers to manufacture wood-plastic composites could mitigate these drawbacks. However, incorporation of wood fibers into plastic not only improves the tensile and flexural properties of the resulting composites relative to pure plastic, but give the composite advantage such as relatively low cost, low equipment abrasiveness and low maintenance requirement (Sherif, et al, 2019; Richard et.al. 2000). Recently, wood – plastic composite played important role in the family of engineering materials, they become prevalent in many build applications basically, in fencing, decking etc (Chukey et al, 2019). This huge resource is referred to waste in the study area. (Linul, et al, 2019) from its investigation, WPCs are of great interest for residential products as well as in automotive applications and the construction industry, wood-plastic composite as emerging materials serve as alternatives to solid wood for various fixtures, such as fencing, window frames and roofing. Accordingly, the objective of the current study is to investigate the mechanical properties of the composites made from two known species. Clyne, 2019; Zagho et al, 2018 investigated the effect of particle size on the mechanical properties of wood-plastics composites. The composite particle size used was 0.6mm with high-density polyethylene as a composite matrix, from the study; the particles contribute better mechanical properties of WPCs due to higher length to thickness ratio. The report was confirmed in the study on WPCs with virgin industrial wood particles used in the production of particle board.Monteiro et.al 2018; Movahedi and Linul, 2017; Adefisan and Adesope 2012 investigated the mechanical properties of bamboo-epoxy composite for structural purposes (loading bearing); from the study, the mechanical properties of bamboo fiber reinforced epoxy composite were studied, the composite fabricated using short bamboo fiber at four different fiber loading; it was observed that, few mechanical properties increase significant with respect to fiber loading.

2. Materials and Method

2.1 Material preparation of wood particles

The major raw materials used for fabrication of the composite are particles from *Pterocarpus angolenesis* and *Gmelina arborea.* The particles were collected from Akim saw mill Calabar, Nigeria. The particles were collected separately from the mill; air dried for five days, to aid the sieve analysis. The particles were sieved with five sieved sizes. The sieve process of each of the particles of *Pterocarpus* and *Gmelina* was performed separately, 500g of air dried samples. Each sample was placed on the top sieve and shaken on an analytical shaker for 25min. The sieved particles were oven dried under a control temperature of 102^0C for 45min.

2.3 Polyester

The polyester used in the research study. Its density was 0.9g/cm^3, and it melt flow index was 54g/10min (230^0C/216kg), the polyester was received from Nigeria raw material research institute, Nigeria. Methyl ether ketone peroxide was employed as accelerator with specific *gravity;1.77g/cc.*

2.4. Preparation of wood plastic composites

Injection method was employed for fabrication of composite, the wood mixture of *Pterocarpus* and *Gmelina* of same sieved sizes wood particles, polyester and Methyl ether ketone peroxide were batch mixed for production in single –screw extruder, the heating temperature profile of the screw were set as 150^0C in feed zone, the screw speed was 60 revolutions per minute and the die size is 5mm. the pallet were injected into mold for proper curing. Table 1 shows the formulation of wood-plastic composite. The specimens were condition at a temperature of 23±2 ^{oC} and relative humidity of 50±5^{o}C according to ASTMD 618-99.

Table 1: Formulation for wood –plastic composite.

Sieve sizes	Wood particle of P/G (wt. %)	Polyester (wt.%)	MEKP (wt.%)
1.18mm –S_1	200	100	2

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1.36mm –S2	400	100	2
3.35mm –S3	400	100	2
4.25µm---S4	400	100	2
600µm ---S5	400	100	2

P –*Pterocarpus angolensis*, G- *Gmelina arborea* particles; MEKP –Meth ether Ketone peroxide

2.5. Water absorption test

Water absorption test was carried out, from the five sieve sizes used for the study in accordance with ASTM D 570. Before laboratory testing, the weight of each test specimen was measured; and oven dried samples of each composite were soak in distilled water at control temperature for 24hours. The test samples were removed from the water, dry and measured. Total numbers of 25 samples were used for the test; each value obtained represented the average value of 5samples per sieved sizes. The value of the water absorption was calculated using equation (i).

$$WA = \frac{w-wo}{wa} \times 100 \qquad \text{equation (i)}$$

Where WA is the water absorption (%), W_o is the oven dried weight and W is the weight of specimen at a given immersion time t.

Mechanical properties

Mechanical properties of wood-plastic composite were examined in terms of tensile and compressive test, the test was performed using Universal Testing Machine according to ASTM D 1037 and ASTM- D 709, respectively. Total numbers of ten test specimens were tested at crosshead speed of 0.001m/s^2 for tensile and compressive test, respectively conducted at a control temperature 23^{0}C relative humidity of 60%. Each test samples were tested according to ASTM standards dimension respectively. Test values recorded were average values of 5 specimens

3.0 Result and discussion

3.1 Water absorption

Water absorption behavior is important, besides the mechanical properties, of wood –plastic composite WPCs; water resistance of WPCs shows the durability of the material when exposed to the environmental conditions. Fig1. Shows the results of water absorption of the composite after 24hours of immersion with difference sieved sizes that were employed in the study, the result indicates that, the particles of the matrix have influence on the uptake of the water. Composite manufacture with sieved size 1.18mm (S_1) shows higher uptake of moisture, this is

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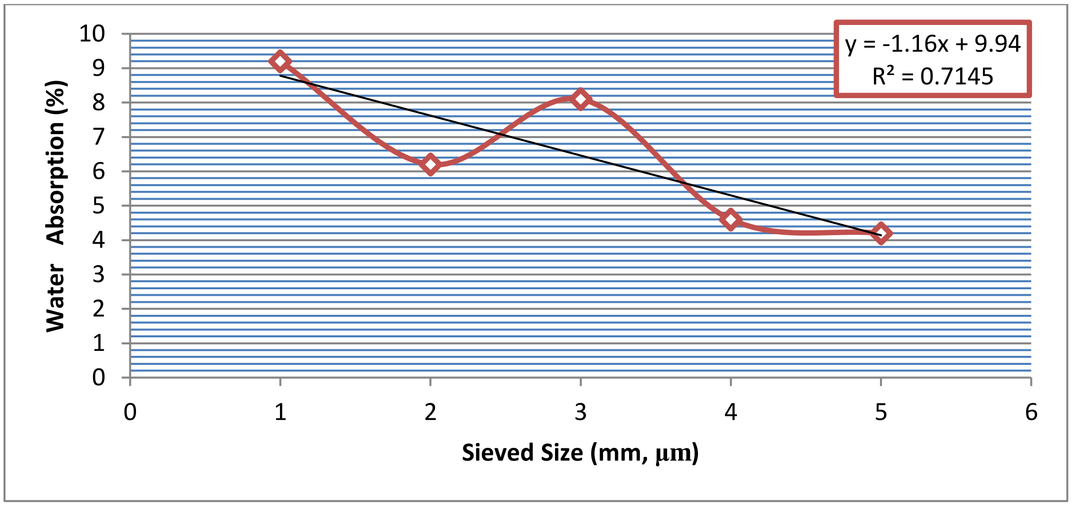
attributed to the hydrophilic nature of wood; the void space generated and micro- gaps at the interface during manufacturing process. Moisture absorptions decreased with composite from sieved size (S_4) and (S_5), absorptions were negligible, and due the particles sizes permit proper inter-facial interaction between the matrix and polyester (hydrophobic nature).

Figure 1: Effect of particles on water absorption

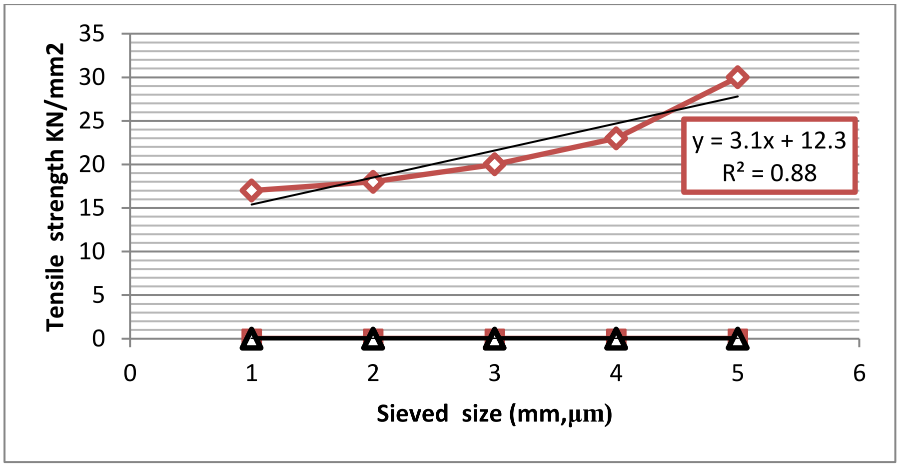


The variation of moisture uptake depends on the difference particles sizes produced; therefore, the particles size has influence on the uptake of moisture of composite.

3.2 Tensile properties

The tensile strength results showed that, composite manufactured from sieved size (S_1) and (S_2) exhibited low average values compared to other samples. S_1 samples shows higher degree of brittleness were observed, the particles size has influenced on the interfacial interaction, resulting to low bonding capacity and micro –crack as equally reported by (Chukoy, et. al, 2019; Adefisan et.al. 2016) Samples from S_3, exhibited moderate tensile strength compared to S_1 and S_2. The samples manufactured with sieved size S_4 and S_5 has higher tensile strength value. The tensile strength of composite was mainly influenced by the filler fraction and the interfacial adhesion between particles and matrix. Higher bonding capacity was observed with samples from S_5, a similar observation was reported for another lingo-cellulosic composite (Linul et. at, 2018; Longxi et, al, 2021,). Figure 2, shows the Tensile strength of composite in relation with the various sieve sizes.

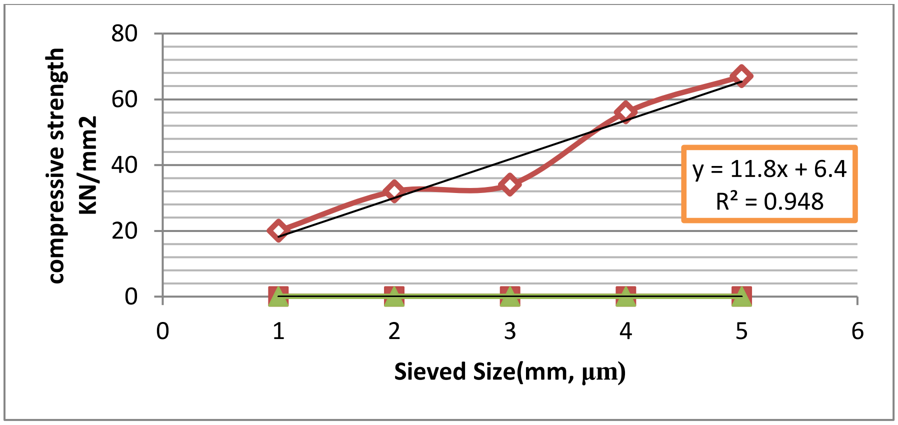
Figure 2: effect of particles on tensile strength



Compressive properties

Compressive strength of the composite differs significantly with different sieved size employed in the study; the compressive properties of the composite basically depended on the interfacial interaction and its properties constituents. The composite produced from sieved sizes label S_1 and S_2 term to exhibit low compressive strength. While the composite produced from particles S_3, S_4 and S_5 has a progressive strength, this is attributed to better interfacial interaction in the WPCs which enable proper and effective stress transferring from matrix to fiber and leading to higher compressive strength recorded. The strength is shown in fig 3.

Figure 3: Effect of sieved size to compressive strength



The sieved size S_5 has the highest compressive strength from the study; this revealed that, the particles size of wood fiber has tremendous influence on mechanical properties of wood plastic composites (WPCs).

CONCLUSION

This study showed the influence of particles size on physical and mechanical properties of wood –plastic composite. Five (5) sieved sizes were employed for this study, labeled S_1 to S_5. Water absorption of composite with S_1, S_2 and S_3 shows higher uptake of moisture and low mechanical properties, while sample made from S_4 to S_5 has lower uptake of water absorption and progressive increase on the mechanical properties examined. The sieved S_5 has lower intake of moisture and higher strength properties, this is attributed to fine particles produced which enhanced interfacial interaction between the matrix and it constituent.

Reference

Adefisan, O.O and Adesope (2012). Assessment of the strength and sorption Properties of Nigerian made Wood Plastic Composite. The Proceeding of 3nd Biennial National Conference of the forest and forest products Society of Nigeria. 138 -140pp.

Adefisan, O.O., Fabiyi, J.S and Englund, K. (2016), Strength and thermal stability of Fiber reinforced Plastic composites made from Rattan canes. *African journal of Sustainable Development* Vol. 6.No. 2:283 -294.

Adefisan, O.O., Wei, L. and McDonald, A.G. (2017). Evaluation of Plastic composite made with Laccosperma secundiflorum and Eremospatha, macrocarpa Canes. *Maderas- Ciencia Technologia* Vol.19.No.4:517-524

ASTM International (ASTM D570-98), 2003, Standards Specification for Plastic Based Composites. Annual Book of ASTM Standards. Conshohocken, PA, 04(03);10356 -1440

Chukov, D.; Nematulloev, S.; Torokhov, V.; Stepashkin, A.; Sherif, G.; Tcherdyntsev, V.(2019) Effect of carbon fiber surface modification on their interfacial interaction with polysulfone. Results Phys., 15, 102634.

Chukov, D.; Nematulloev, S.; Zadorozhnyy, M.; Tcherdyntsev, V.; Stepashkin, A.; Zherebtsov, D. (2019) Structure, mechanical and thermal properties of polyphenylene sulfide and polysulfone impregnated carbon fiber composites. Polymers 11, 684.

Clyne, T.W.; Hull,D.An Introduction to Composite Materials, 3rded.; Cambridge University Press: Cambridge, UK, 2019.

Emmanuel, P. Nicholas, K.P. Padmanaban,P. O. (2021) Optimization of Dispersed Laminated Composite Plate for Maximum Safety Factor Using Genetic Algorithm and Various Failure Criteria, Procedia Engineering, Volume 38. Pages 1209-1217, ISSN 1877-7058.

Lebreton, L.C.M.; van der Zwet, J.; Damsteeg, J.W.; Slat, B.; Andrady, A.; Reisser, J. River plastic emissions to the world's oceans. Nat. Commun. 2017, 8, 15611.

Linul, E.; Lell, D.; Movahedi, N.; Codrean, C.; Fiedler, T. (2019) Compressive properties of Zinc Syntactic Foams at elevated temperatures. Compos. Part B Eng. 167, 122–134.

Linul, E.; Vălean, C. and Linul, P.A. (2018) Compressive behavior of aluminum microfibers reinforced semi-rigid polyurethane foams. Polymers 2018, 10, 1298

Liu, P.F and Zheng, J.Y(2021). Recent developments on damage modeling and finite element analysis for composite laminates: A review, Materials & Design, Volume 31, Issue 8, September 2012, Pages 3825-3834, ISSN 0261-3069.

Monteiro, S.N.; de Assis, F.S.; Ferreira, C.L.; Simonassi, N.T.; Weber, R.P.; Oliveira, M.S.; Colorado, H.A.; Pereira, A.C.(2018) Fique fabric: A promising reinforcement for polymer composites. Polymers 2018, 10, 246.

Movahedi, N and Linul, E. (2017) Quasi-static compressive behavior of the ex-situ aluminum-alloy foam-filled tubes under elevated temperature conditions. Mater. Lett. 2017, 206, 182–184

Richard, F. and Perreux, D. (2000) A reliability method for optimization of [+ϕ,−ϕ]n fiber reinforced composite pipes, Reliability Engineering & System Safety, Volume 68, Issue 1, April 2000, Pages 53-59, ISSN 0951-8320.

Sherif, G.;Chukov,D.;Tcherdyntsev,V. and Torokhov,V. (2019)Effect of formation route on the mechanical properties of the polyether sulfone composites reinforced with glass fibers. Polymers 11, 1364.

Yashas Gowda, T.G.; Sanjay, M.R.; Subrahmanya Bhat, K.; Madhu, P.; Senthamaraikannan, P.; Yogesha, B. SS (2018) Polymer matrix-natural fiber composites: An overview. Cogent. Eng. 5, 1446667.

Yongxu, D.; Dong, L.; Libin, L. and Guangjie, G. (2021) Recent achievements of self-healing graphene/polymer composites. Polymers 2018, 10, 114.

Zagho, M.M.; Hussein, E.A.; Elzatahry, A.A. (2018) Recent overviews in functional polymer composites for biomedical applications. Polymers 2018, 10, 739