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Abstract. Green composites have gotten a lot of awareness in the composite industry lately because the whole world is driving toward sustainability whereas conventional composites are usually prepared from petroleum products which are usually non-degradable and result in environmental pollution. This paper presents a succinct review of the composite materials produced from green composites with a potential of being applicable in automotive body parts, aircraft body parts, medicine, construction etc. The review classifies the different research works done into six groups, then identifies gaps in research with the aim of charting a course for future researchers. Also, the review is very essential to manufacturers as they can be kept abreast with the latest developments in green composites which could replace some of the conventional composites used in the manufacturing industry.

Keywords: Green Composite, Mechanical Reinforcement, Polymer.

1 INTRODUCTION

Composite is a blend of materials with different properties; these could be physical properties, chemical properties or both [14]. The diverse materials are ordinarily recognized as dispersed stage (reinforcement) and matrix stage [12]. The reinforcement is the part bearing the load while the matrix part holds the fortifying parts together and afterward shares the load amongst the parts. Both matrix and reinforcement materials have separate properties, yet when they are consolidated, it gives a material which has better properties than the parent materials [21], [31-33].
Composites are of varying kinds based on matrix classification as; Polymer-matrix, Ceramics-matrix and Metal-matrix. Polymer composite is usually of more prominent interest to most specialists since it has high quality, high firmness, light weight, and simplicity of manufacturing. In the composites, the matrix used is a polymer (as the name suggests), often hydrocarbon based whereas, the reinforcement used will be synthetic fibers, usually made of carbon or glass strands [34].

Because of the advantages of these polymers, they are supplanting metals in many fields, for example, aviation, vehicle, sports equipment and so on. [9], [15], [20]; [25], [26], [30]. The manufactured polymer composites are additionally generally petroleum-based items. Numerous analysts are searching for choices to supplant these petroleum-based composites because of the growing awareness of petrochemical resources. This move is additionally proposed to diminish the carbon footprint on earth [15].As world societies emerge, more emphasis is being set on guaranteeing the sustainability of materials; new themes are presently finding a direction among material producers. Such points include greenhouse-gas emissions, toxicity, energy associated with building construction, and depletion of

resources [8]. Developing environmental challenges and the depletion of oil assets which were made by production of composites and non-biodegradable plastics have motivated a developing enthusiasm for creating eco-friendly and biodegradable composites and green polymers [29].

During the most recent couple of decades, because of the limitations of regular crude materials, consistently expanding issue of environmental degradation and extremely fierce controls forced by most governments, the chemical sector has tilted towards the idea of green chemistry; the outcome of these are polymers and composite materials made from natural fibers[7]. Currently, specialists are focusing on polymers made by sustainable and earth amicable materials that are by and large more accessible. The restored focua has incited the usage of natural filaments alongside matrices for this new wave of polymer composites. Research now shows that energy used in the making of natural filaments is about half of what is required for generation of unnatural fibers. The advantages that accrue to using natural fibers include light weight, non-irritating, burnable, non-abrasive, non-lethal, and biodegradable to refer to a couple [2]. The usage of natural strands for help in composites dates to around 10,000 years. An extraordinarily common model is the use of plant filaments as a help material in construction during Pharaoh's time in Egypt. Henry Ford in like manner made a whole auto body using just hemp fiber[27]. Common fibers have been found to have incredible heat insulation and acoustic properties. They can moreover be used for improvement of auxiliary boards and sandwich pillars required in lodging ventures. The extent of work which should be possible with natural fibers going about as development materials is huge considering their superiority with regards to maintenance, strength, and cost adequacy [30].

1.1 Composites from Green Products

Green composites otherwise called composites from green products are for the most part made of natural fibers and bio-polymers. The motivation behind why they are called green is claiming they are gotten from natural resources and are accordingly sustainable since they can't be depleted. Some examples of natural fibers are coir, sisal, hemp, flax and so forth while those of bio-polymers include CNSL, starch, furan, poly lactic acid (PLA) and so on [35].

1.2.1 Natural Fibers

Naturally existing fibers are primarily arranged into protein based, cellulose based and mineral based [11] Fig.1 demonstrates the classifications of natural fibers.

Vegetable based filaments can be additionally arranged by origin into: seed, leaf, grass, stalk and bast. Fibers from stem, bast and leaf are normally sorted out into packs and can therefore be called fiber packs whereas fibers from seed are usually found singly single cells and can be called fibers[27]. On the other hand, naturally occurring fibers primarily consist of three vital parts: hemicellulose, lignin and cellulose. Cellulose is the fundamental segment which oversees ingrained strength and stability of the natural fiber whereas hemicellulose adds to the structure [3]. For the most part, in rural areas, the common filaments are utilized widely for applications that don't really deal with structure, for example furniture, broom, rope, and bag. The fibers are likewise utilized for heat insulation and roofing. They have coarse surfaces and usually have colours ranging from white to deep brown[1].

1.2.2 Biopolymers

Tang *et al.,* (2012) perceived two sorts of biopolymers which are those that are from living beings and those which came from polymers from natural resources and are therefore

biodegradable. Contemplating this, the principal category incorporates polysaccharide (cellulose, starch, chitosan etc) and protein (keratin, collagen, gelatin, et cetera.); the second one is all around indicated by polylactic acid. In any case, [3] described polymers from feasible resources into three critical social events: characteristic polymers, for instance, cellulose and starch; designed polymers which are from typical monomers for instance, PLA; those coming from microbial aging for instance, poly-hydroxy-butyrate (PHB). He affirmed that PLA is one of the most important biodegradable polymers and it can be gotten from feedstock. Examples include corn starch which can also be gotten from various plants such as potatoes, rice, and other agrarian remains.

2 Development of composite materials

2.1 Batteries

The regularly utilized anode material for business LIBs (Lithium Particle Batteries) is graphite nonetheless, because of the generally low hypothetical limit (372 mAhg-1), new composites must be produced for expanding vitality requests without bounds [23]. combined the α-Fe2O3@nitrogen doped carbon composites got from microalgae utilizing shower pyrolysis, which demonstrated a large release limit of 1281.5 $mAhg^{-1}$at 100 mAg^{-1} as anode substance for lithium particle stockpiling. The explanation behind the investigation depended on the requirement for high vitality and power densities with a minimal effort auxiliary battery framework in electric vehicles. The α-Fe2O3@nitrogen doped carbon likewise gave great rate execution in a scope of 200 mAg-1 - 1000 mAg-1, and kept up a limit of 92% after 100 cycles at 200 mAg-1. It showed both enhanced electrical conductivity and compelling aversion of the increase in volume of iron oxide amid battery release/charge by splash pyrolysis process. [6] effectively biosynthesized titanium dioxide nanoparticles utilizing remainder water (in a perfect world kitchen squander) gathered from drenched Bengal gram beans which ensured that the method was green. Steady and non-accumulated nanoparticles with tight size conveyance was shaped, or, in other words X-beam diffraction estimation and transmission electron microscopy examination. The union procedure that was utilized was simple, safe, financially savvy and adaptable, along these lines tending to the green science standards. At that point nano-particles enhanced the execution and cycling security of the phone by shortening the way lengths for both Li-particle and electron transport and bringing down the current thickness. The union technique utilized in the work gives a conceivably valuable strategy to creating anodes for high-control Li-particle batteries since it is greener than past strategies and it is additionally basic.

2.2 Composite Resins

Urea-Formaldehyde resin is the most broadly utilized adhesives used in wood-based composites however because of the push for a greener society and the worries the pitch raised, for example, poor water obstruction and free formaldehyde discharge, upgrades on the sap must be made. [24] created "greener" cements made from urea-formaldehyde (UF) tar and cottonseed feast for wood-based composites. The greener cement made from UF tar and cottonseed dinner was effectively arranged by a typical engineered procedure of unadulterated UF tars. After a few examinations were made on the new cement, it was discovered that the UF gum with 40% by weight of cottonseed feast gave better mechanical quality, rheological property and comparable warm dependability and compound structure as the unadulterated tar. The greener cement adequately enhanced the execution of unadulterated UF saps while holding its exceptional highlights in this way proposing the attainability of utilizing it as UF gums in assembling lines for wood-based composites.

2.3 Composite Fibers

[28] proposed a greener methodology of enhancing the interface and execution of plant fiber composites utilizing microcrystalline cellulose. This appears differently in relation to the traditional technique for enhancing exhibitions of plant fiber composites by fiber surface alteration; the investigation utilizes a novel methodology dependent on the scattering of MCC (microcrystalline cellulose) in the grid. The expansion of microcrystalline cellulose to the network of jute fiber/epoxy composites was observed to be exceptionally viable in creating various leveled composites with prevalent fiber/framework interface and additionally mechanical and warm exhibitions as against the perfect jute fiber composites. Because of MCC expansion, flexural, pliable and Izod affect qualities of jute/epoxy composites enhanced by 21.5%, 18.4% and 28.3% individually coming about because of the enhanced interface and strengthening impact of MCC precious stones; the solidifying of epoxy atoms because of the nearness of MCC organizes additionally prompted real upgrades in both the capacity modulus and damping element or failure modulus of composites. It was inferred that MCC can be profitably utilized as an elective green material to CNTs (Carbon Nanotubes) for creating fiber based progressive composites.

2.4 Mechanical Strength

[18] examined the impact of chosen properties of including paper slurry, rice extract and husk into composites of woods to particles of wood for assembling green pallets. After effects of the examination show that wood-paper composites have quite a few mechanical properties that can be influenced upon the utilization of an elective material such as paper slurry into particles of wood to aid in the creation of green pallets, using rice husk and straw as a substitute brought about a lessening in mechanical quality as the stacking content was expanded. It is proposed that blending of particles of wood and paper sludge that has been dried can create an appropriate composite of wood-paper sludge alternative material for restricted particle board made of wood as green pallet reinforced by formaldehyde-based tar.

2.4.1 Long and Safe Service

[17] created self-mending protein lone-microfibrillated cellulose composites that fused poly(d,l-lactide-co-glycolide) microcapsules containing (SPI-PLGA-MCs) as the recuperating agent. The motivation behind self- recuperating framework could be to elongate the green composite's life. The novel self-mending SPI composites might be utilized in numerous situations where oil determined composites are at present being utilized for safety and durability of service.

2.4.2 Water Resistance

[13] used a blend of particles made of wood and glass fibers to create particle boards, as the most central part and two segments of woven jute texture as skin layers utilizing a vacuum tar exchange shape. It was shown that the proposed sandwich composites displayed dimensional firmness and brilliant water opposition when contrasted with composites of wood that are commercial. Outcomes additionally recommended that these green composites which are hybrid with improved execution would be utilized in automobile and the fabrication & manufacturing sectors.

2.4.3 Flexural Strength

According to [22], composites dependent on common fiber support have produced wide research and drive for designing for the most recent couple of years because of their particle quality is high, little thickness, ease, recyclability, biodegradability and light weight and they have gained an exceptional green composite classification. Sundi wood dust composite was prepared with seven diverse % filler weight. At three unique velocity, the flexural and tensile test were performed to consider the mechanical conduct of the composites. The consequences of the trial demonstrated that effective fabrication of the sundi wood dust fortified epoxy composites was conceivable and that the sundi wood dust has great filler attributes as it enhances both flexural and tensile properties. The best mechanical properties were examined for 10% filler weight and speed of 1mm/min and 2 mm/min speed.

2.4.4 Machinability

According to [5], environmentally friendly materials are rising in the automobile and aviation enterprise because of numerous advantages for feasible improvement provided. In any case, machining normal fiber reinforced plastic composites is these days a genuine trial for the academia and industries. It is therefore important to foresee their machining forms for coordinating them into the NFRP mechanical creation chains. They in this manner explored the warm impact on the machinability of unidirectional flax filaments strengthened polypropylene composites (UDF/PP) with respect to the cutting contact geometry. Symmetrical cutting of UDF/PP composites was performed under various device rake edges and test temperatures with the end goal to examine the thermal effect on the tribological cutting conduct of flax filaments in composite materials. One of the real discoveries is that poor flax fiber shearing is the fundamental purpose behind expanding the machined surface roughness by expanding the whole filaments furthest points on the machined surface. The investigation additionally permitted the deciding of another applicable parameter of NFRP machinability situated in the cutting friction.

2.4.5 Polishing

Effective completing and machining of natural-fiber-strengthened-plastic (NFSP) composites is basic for understanding the modern use conceived of these earth friendly materials [4]. The study describes the thermal effect amid the polishing of NFRP composites. Dry and wet polishing were performed following a few polishing ventures on unidirectional flax filaments reinforced polypropylene composites. To get dependable outcomes, each considered polishing test was rehashed three times under indistinguishable conditions with another SiC abrasive paper at each time. It was found that dry polishing prompted less surface imperfections in the composite surface because of the temperature increment that makes the material softer and thereby evades the fragile crack of the fibers/lattice interfaces. Additionally, the impact of polishing condition (dry or wet) was found to influence the surface harshness where dry polishing creates smoother surfaces than wet polishing.

2.5 Medicine

Dumbrava [10], explored the displacement of zinc oxide onto calcium carbonate accelerate utilizing a format of polysaccharides from Ulvalactuca green sea weeds (Black Sea). These seaweeds were distinguished as an imperative wellspring of polysaccharides in this way recommending their wide use as biopolymers for the union of inorganic materials by biotechnological techniques. The new composite material determined consolidates the highlights of zinc in skin capacities, (for example, repair, antioxidant, preservation) with

those of calcium particles, (for example, hemostatic, keratinocytes development) and algal polysaccharides (cell reinforcement, absorbent and anti-inflammatory). It was additionally exhibited that the created composite material could be connected as wound dressing to accelerate the skin mending process.

3 CONCLUSION

From the literatures reviewed above, it shows that a lot of effort has been put into the development of green composites especially because of the global concern of sustainability. Most available literature investigates how these newly developed composites compare to the conventional ones mechanically; several mechanical properties such as thermal stability, tensile strength, stiffness etc. have been evaluated and considerable progress in the development of green composites is evident. Other sectors such as manufacturing, medicine, battery technology etc. are also concerned with green composites even though there is still a long way to go as far as research is concerned in those areas.

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REFERENCES

[1] A. Ticoalu, T. Aravinthan & F. Cardona, A review of current development in natural fiber composites for structural and infrastructure applications, Southern Region Engineering Conference, 11-12 November 2010, Toowoomba, Australia

[2] Olusegun David Samuel, Stephen Agbo, Timothy Adesoye Adekanye, Assessing Mechanical Properties of Natural Fibre Reinforced

[3] Malinowski, P. H., Ostachowicz, W. M., Touchard, F., Boustie, M., Chocinski-Arnault, L., Gonzalez, P. P., … Sorrentino, L. (2018). Study of plant fibre composites with damage induced by laser and mechanical impacts. Composites Part B: Engineering, 152, 209–219. https://doi.org/https://doi.org/10.1016/j.compositesb.2018.07.004

[4] Chegdani, F., Bukkapatnam, S. T. S., & Mansori, M. El. (2018). Thermo-mechanical Effects in Mechanical Polishing of Natural Fiber Composites. Procedia Manufacturing, 26, 294–304. https://doi.org/https://doi.org/10.1016/j.promfg.2018.07.038

[5] Chegdani, F., Takabi, B., Tai, B. L., Mansori, M. El, & Bukkapatnam, S. T. S. (2018). Thermal Effects on Tribological Behavior in Machining Natural Fiber Composites. Procedia Manufacturing, 26, 305–316. https://doi.org/https://doi.org/10.1016/j.promfg.2018.07.039

Composites for Engineering Applications, Journal of Minerals and Materials Characterization and Engineering, 2012, 11, 780-784

[6] Anil A. Kashale, Ketan P. Gattu, Kalyani Ghule, Vijay H. Ingole, Swapnali Dhanayat,Ramphal Sharma, Jia-Yaw Chang, Anil Vithal Ghule.Biomediated green synthesis of TiO2 nanoparticles for lithium ion battery application. Composites Part B 99 (2016) 297–304.

[7] Dey, P., & Ray, S. (2018). An Overview of the Recent Trends in Manufacturing of Green Composites – Considerations and Challenges. Materials Today: Proceedings, 5(9, Part 3), 19783–19789. https://doi.org/https://doi.org/10.1016/j.matpr.2018.06.341

[8] Dicker MPM, Duckworth PF, Baker AB, Francois G, Hazzard MK, Weaver PM. Green composites: a review of material attributes and complementary applications. Compos Appl Sci Manuf 2014; 56:280–9.

[9] Dicker, M. P. M., Duckworth, P. F., Baker, A. B., Francois, G., Hazzard, M. K., & Weaver, P. M. (2014). Green composites: A review of material attributes and complementary applications. Composites Part A: Applied Science and Manufacturing, 56, 280–289. https://doi.org/https://doi.org/10.1016/j.compositesa.2013.10.014

[10] Dumbrava, A., Berger, D., Matei, C., Radu, M. D., & Gheorghe, E. (2018). Characterization and applications of a new composite material obtained by green synthesis, through deposition of zinc oxide onto calcium carbonate precipitated in green seaweeds extract. Ceramics International, 44(5), 4931–4936. https://doi.org/https://doi.org/10.1016/j.ceramint.2017.12.084

[11] Eustathios Petinakis, Long Yu, George Simon and Katherine Dean Natural Fibre Bio-Composites Incorporating Poly(Lactic Acid), Fiber Reinforced Polymers - The Technology Applied for Concrete Repair, 2013

[12] Fayomi, O. S. I., & Popoola, A. P. I. (2015).Anti-Corrosion and Tribo-Mechanical Properties of Co-deposited Zn–SnO 2 Composite Coating. *ActaMetallurgicaSinica (English Letters)*, *28*(4), 521-530.

[13] Hassanin, A. H., Hamouda, T., Candan, Z., Kilic, A., & Akbulut, T. (2016). Developing high-performance hybrid green composites. Composites Part B: Engineering, 92, 384–394. https://doi.org/https://doi.org/10.1016/j.compositesb.2016.02.051

[14] Inegbenebor, A. O., Bolu, C. A., Babalola, P. O., Inegbenebor, A. I., &Fayomi, O. S. I. (2018). Aluminum silicon carbide particulate metal matrix composite development via stir casting processing. *Silicon*, *10*(2), 343-347.

[15] M P Westman S G Laddha, L S Fifield T A Kafentzis, K L Simmons, Natural Fiber Composites: A Review, the National Technical Information Service,U.S. Department of Commerce, 2010

[16] Julia cousera∗, Nadezda Stevulova, Alena Sicakova, Jozef Junak, Some Aspects of Lightweight Composites Durability, Chemical Engineering Transactions, vol 32,2013

[17] Kim, J. R., & Netravali, A. N. (2017). Self-healing green composites based on soy protein and microfibrillated cellulose. Composites Science and Technology, 143, 22–30. https://doi.org/https://doi.org/10.1016/j.compscitech.2017.02.030

[18] Kim, S., Kim, H.-J., & Park, J. C. (2009). Application of recycled paper sludge and biomass materials in manufacture of green composite pallet. Resources, Conservation and Recycling, 53(12), 674–679. https://doi.org/https://doi.org/10.1016/j.resconrec.2009.04.021

[20] Koronis G, Silva A, Fontul M. Green composites: a review of adequate materials for automotive applications. Compos B Eng 2013;44(1):120–7.

[21] Krishan K. Chawla, Composite Materials, Science and Engineering, Third Edition, 2013

[22] Kumar, K., Sahoo, P., & Bhowmik, S. (2014). Study of Mechanical Properties of Wood Dust Reinforced Epoxy Composite. Procedia Materials Science, 6, 551–556. https://doi.org/https://doi.org/10.1016/j.mspro.2014.07.070

[23] Kwon, K. M., Kim, I. G., Lee, K.-Y., Kim, H., Kim, M. S., Cho, W. Il, … Nah, I. W. (2018). α-Fe2O3 anchored on porous N doped carbon derived from green microalgae via spray pyrolysis as anode materials for lithium ion batteries. Journal of Industrial and Engineering Chemistry. https://doi.org/https://doi.org/10.1016/j.jiec.2018.09.004

[24] Liu, M., Wang, Y., Wu, Y., He, Z., & Wan, H. (2018). "Greener" adhesives composed of urea-formaldehyde resin and cottonseed meal for wood-based composites. Journal of Cleaner Production, 187, 361–371. https://doi.org/https://doi.org/10.1016/j.jclepro.2018.03.239

[25] Masmoudi F, Bessadok A, Dammak M, Jaziri M, Ammar E. Biodegradable packaging materials conception based on starch and polylactic acid (PLA) reinforced with cellulose. Environ Sci Pollut Control Ser 2016;23(20):20904–14.
[26] Mohanty AK, Misra M, Drzal LT. Sustainable bio-composites from renewable resources: opportunities and challenges in the green materials world. J Polym Environ 2002;10(1–2):19–26.
[27] Mwaikambo, L. Y. REVIEW OF THE HISTORY, PROPERTIES AND APPLICATION OF PLANT FIBRES, African Journal of Science and Technology (AJST),Science and Engineering Series Vol. 7, No. 2, pp. 120 – 133, 2006
[28] Pichandi, S., Rana, S., Parveen, S., & Fangueiro, R. (2018). A green approach of improving interface and performance of plant fibre composites using microcrystalline cellulose. Carbohydrate Polymers, 197, 137–146. https://doi.org/https://doi.org/10.1016/j.carbpol.2018.05.074
[29] Rahman, M. M., & Netravali, A. N. (2018). Advanced Green composites using liquid crystalline cellulose fibers and waxy maize starch based resin. Composites Science and Technology, 162, 110–116. https://doi.org/https://doi.org/10.1016/j.compscitech.2018.04.023
[30] Dayo, A. Q., Zegaoui, A., Nizamani, A. A., Kiran, S., Wang, J., Derradji, M., … Liu, W. (2018). The influence of different chemical treatments on the hemp fiber/polybenzoxazine based green composites: Mechanical, thermal and water absorption properties. Materials Chemistry and Physics, 217, 270–277. https://doi.org/https://doi.org/10.1016/j.matchemphys.2018.06.040
[31] Potadar, O. V, & Kadam, G. S. (2018). Preparation and Testing of Composites using Waste Groundnut Shells and Coir Fibres. Procedia Manufacturing, 20, 91–96. https://doi.org/https://doi.org/10.1016/j.promfg.2018.02.013
[32] Quiles-Carrillo, L., Montanes, N., Garcia-Garcia, D., Carbonell-Verdu, A., Balart, R., & Torres-Giner, S. (2018). Effect of different compatibilizers on injection-molded green composite pieces based on polylactide filled with almond shell flour. Composites Part B: Engineering, 147, 76–85. https://doi.org/https://doi.org/10.1016/j.compositesb.2018.04.017
[33] Suhendro, B. (2014). Toward Green Concrete for Better Sustainable Environment. Procedia Engineering, 95, 305–320. https://doi.org/https://doi.org/10.1016/j.proeng.2014.12.190
[34] Zini E, Scandola M. Green composites: an overview. Polym Compos 2011;32(12):1905–15.
[35] Ahmed H. Hassanin, Tamer Hamouda, Zeki Candan, Ali Kilic, Turgay Akbulut. Developing high-performance hybrid green composites. Composites Part B 92 (2016) 384-394.
[36] Jiang, S., Yang, Y., Ge, S., Zhang, Z., & Peng, W. (2018). Preparation and properties of novel flame-retardant PBS wood-plastic composites. Arabian Journal of Chemistry, 11(6), 844–857. https://doi.org/https://doi.org/10.1016/j.arabjc.2017.12.023