ISSN 2395-1621

A Review on Recent Developments and Future Prospect of Wood Plastic Composites

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ABSTRACT

Wood-plastic composites (WPCs) with features having excellent water resistance, non-abrasive, mechanical properties, and thermal stability are deemed to have increased influence on solid waste management and rural economy .Rapid urbanization and industrialization of suburban and rural areas has been creating substantial wastes. Hence, WPCs developed by reusing waste materials such as high, plastics, papers, recycled WPCs, etc. are very lucrative for various industries. This paper presents a detailed review about recent improvements & trends for WPCs especially the materials and processing challenges affecting the interface and functional performance of wood polymer composites (WPCs). Nano-scale coating and reinforcement in WPCs for thermal stability and interfacial strength and effect of structural changes of wood flour by various treatments on flexural properties.

Keywords— Wood plastic composites, hybrid composites, natural fibres, thermoplastics, chemical assembly, fracture resistance, accelerated weathering.

ARTICLE INFO

Article History

Received: 28th February 2016

Received in revised form :

1st March 2016

Accepted: 3rd March 2016

Published online :

5th March 2016

I. INTRODUCTION

“Wood plastic composite” (WPC) a composite that contain plant (including wood and non-wood) fibresas reinforcement and a thermoset or thermoplastic polymer matrix. Thermoplastics include resins such as acrylonitrile butadiene styrene (ABS), polylactic acid (PLA), polyethylene (HDPE, LDPE), polypropylene (PP) and polyvinyl chloride (PVC). Thermosetting include resins such as epoxies, esters and phenolics.Manufacturing process such as extrusion, injection and compression moulding are used to develop WPCs of high dimensional tolerances, are tough and stable products. They have good mechanical properties, high dimensional stability, ultraviolet resistance, do not corrode, highly resistant to rot, workability and hydrophobicity. To produce complex shapes by compression moulding which is very commendable and unique as it contains natural fibres or wood flour or both. For WPCs costreduction andwaste utilisation large amounts of natural fibres generated in wood based industries is used in both structural and non-structural applications. Wood plastic composites (WPCs)have been developed are having properties such low density, high flexural modulus, non-abrasive, better dimension stability, and aesthetically pleasant. Applicability of WPCs has gone wider from automotive, building and construction as now being utilized forfurniture, technical parts, consumer goods and household electronics, marine applications.Substantial amount of research works on WPCs have been published most of them have investigated the mechanical, thermal and morphological properties of WPC, and how they are affected by the addition of natural fibres, wood flours, and additives such as colorants, coupling agents, UV stabilizers, blowing agents, foaming agents, and lubricants.Wood-Plastic-Composites (WPCs) gaining interests among wood based industries and consumers as green technology which helps to reduce landfill and global issues, while also due to their potential practicability.

II. MATERIALS AND METHODS

2.1 Effects of surface modification of wood fibres on the interface and functional performance of WPCs.

The fibre and matrix adhesion mechanism shown to be proportion to the disruption of hydrogen bonding in the wood flour network. As microstructural pores of the wood flours became clearer. Process was completed by leaching the waxy cuticle layer, proportionally increasing treatment of the alkaline time to 150 min kept soaked in 4wt% NaOH concentration. The surface of the wood fibre appeared curly and soft upon alkaline treatment. This resulted in the enhancement of mechanical interlocking at the interface which lead to an increase in desirable functional properties as alkaline concentrations reached 4 wt%. Subsequently, functional properties reduced at higher concentrations, while it increased with treatment time upto 150 min. Acetylation process was implemented by treating natural fibres with acetic or propionic acid at elevated temperatures with or without an acid catalyst. It affects the substitution of the hydroxyl groups of the cell wall with acetyl groups of natural fibres, thereby, enhancing its hydrophobic nature with a view to imparting stronger interfacial adhesion of the natural fibre with the polymer matrix so as to reduce the moisture absorption of the WPCs.

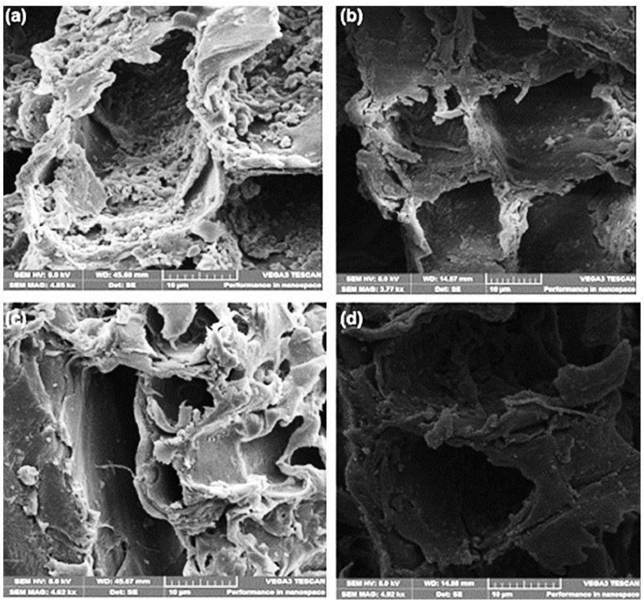


Fig. 1. SEM images showing the surface morphologies of (a) untreated wood fibres; and wood fibres treated for (b) 30 min; (c) 90 min; (d) 150 min in 4 wt. % Nao solution [2].

Meanwhile, (Olakanmi. 2016) showed that effective stress transfer across the wood fibre-polymer interface improved by surface modification techniques employing compatibilisers and coupling agents. Also, the interfacial adhesion and reinforcement improved upon addition of maleated polypropylene (MAPP), non-reactive surface modification lead to a moderate decrease of interaction, while benzylation decreased interfacial adhesion and water absorption quite considerably. Independent of the amount of coupling agent used, MAPP did not influence homogeneity, viscosity and water absorption; surfactants improved homogeneity and processability.Another process, plasma treatment is an environmentally friendly technology which alters the surface properties of wood fibres without altering its bulk properties. These variants of plasma treatment are commonly characterised by an ionised gas having an equivalent number of positively and negatively charged molecules which react with the surface of the wood fibre. However, these types of plasmas are distinguished from each other by the frequency of electric discharge. Meanwhile, plasma treatment cleans and modifies the wood fibre via impartation of various functional groups and alteration of surface energies.

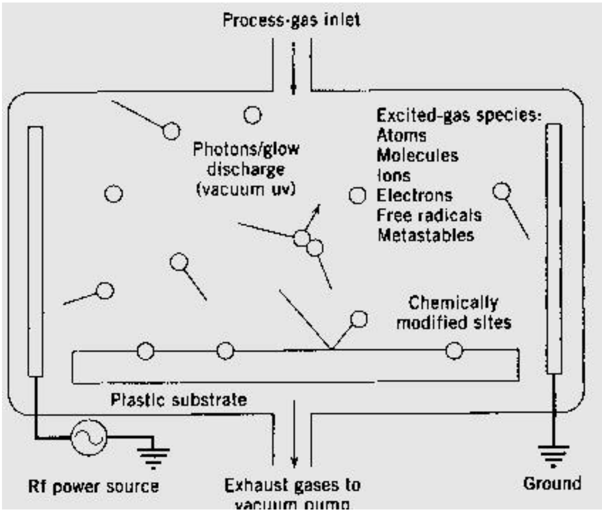


Fig.2 plasma treatment done to plastic substrate for activation [5].

2.2 Effect of Nano-Zno coating on the surface of wood plastic composite based on propylene.

(Xianzhu Ye et al., 2015) showed that coating of Nano zinc-oxide-coating via ion assembly improves WPC interfacial strength and load transfer, addition to better UV and Infrared resistance.

The cell wall contains mainly cellulose, lignin, etc. cellulose has large number of hydroxyl groups which are exploited by active nano-ZnO to construct an efficient Nano-coating on the wood surface, allowing construction of a dispersivethree-dimensional Nano-interface in WPCs.

This Ionic self-assembly carried out by cationic polyethyleneimine-ZnO (PEI-ZnO) and anionic sodium polyacrylate-wood fibre (PAAS-wood). Explaining the branched PEI with high electric density and activity can allow reaction of inorganic particles with the hydroxyl groups on surface, efficiently making nano-ZnO cationic. As it is grafted on wood surface, followed by ultrasonic treatment, cationic PEI-ZnO particles were absorbed by PAAS-wood. Making it more suitable for chemical assembly.

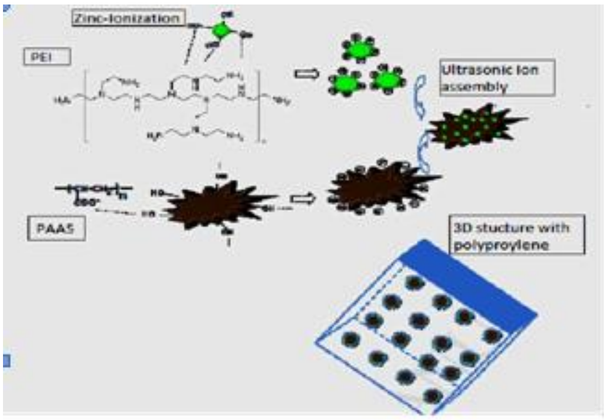
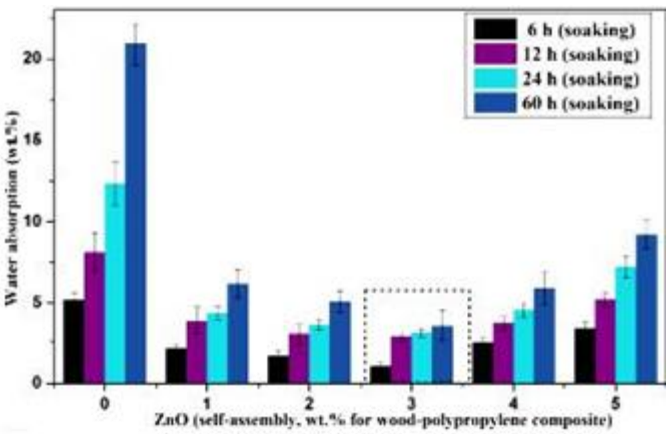


Fig. 3. Ionic self-assembly carried out by cationic polyethyleneimine-ZnO (PEI-ZnO) and anionic sodium polyacrylate-wood fibre (PAAS-wood) [1].

Importantly, mechanical properties, viscoelasticity, and the thermal stability of composite with assembling Nano-interface were improved for the adhesive and dispersive Nano-network. The flexural properties and the tensile strength of composite with 3 wt.% Nano-interface was enhanced about 90%. With a three-dimensional nano-shielding effect, separation in ultraviolet-visible-near-infrared light was also reinforced as well as the water resistance, which decreased from 5.20 wt.% to 1.83 wt.% after soaking for 6 h.

Sample	Tensile properties			Flexural properties		
	Tensile Strength (MPa)	Elastic Modulus (MPa)	Elongation At Break (%)	Flexural Strength (MPa)	Flexural Modulus (MPa)	Largest Flexural force (N)
Pure composite	20.42±1.39	2308.22±89.2	1.63±0.18	52.21±2.89	226.40±9.2	30.56±2.17
composite-1 wt.%	29.20±2.14	2712.32±107.3	1.99±0.23	56.88±2.31	298.60±11.1	39.45±2.31
composite-2 wt.%	32.12±2.68	2889.29±123.7	2.29±0.38	57.12±2.19	304.20±7.2	42.12±1.60
composite-3 wt.%	38.73±2.12	3121.6±108.2	2.43±0.27	66.29±2.34	336.70±11.2	45.849±2.4
composite-4 wt.%	31.39±3.21	3022.1±156.1	2.12±0.28	61.18±2.67	312.20±8.99	43.12±1.21
composite-5 wt.%	27.33±1.29	2631.2±112.6	2.04±0.19	55.38±2.16	287.16±4.23	36.29±2.15

Fig. 4. Composites tensile and flexural behaviours of composites with varying wt.% [1].



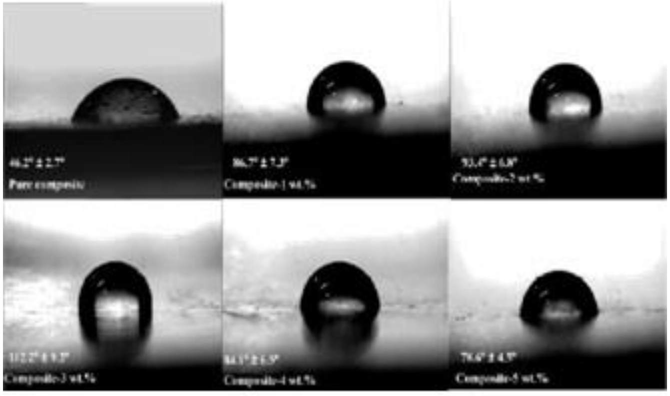


Fig. 5. Water absorption and contact angle of composites with different Nano-assembling ratios [1].

III. CONCLUSION

This review promoting WPCs proffered potential practicability as literature findings on recent works on Nano-based WPCs and surface-modification methods to increase the fibre and surface adhesion. Recent works on surface modification to improve the load transfer from matrix to fibre, provides insight of the processing methods, which affect the interface and functional properties of WPCs. Meanwhile, few studies are available in regards to the processing and characterisation of hybrid and Nano based WPCs. To overcome various issues based on WPCs such as biodegradability, incompatibility, etc. further studies must be directed towards addressing these issues. The opportunities they offer for structural applications is wide and huge. WPCs must be seen as potential benefit to the society to reduce waste and effect a transformation in use of plastic based composites in remotest of earth.

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