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MECHANICAL ASPECTS OF POLYMER COMPOSITES REINFORCED WITH NATURAL FIBERS AFTER ONE YEAR OF WATER IMMERSION

V Ramesh (Research Scholar)
Dr. Harbeer Singh (Associate Professor)
(Research Supervisor)
Glocal School of Science

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Abstract

Natural fiber (NF)-grounded polymer composites (PCs) have the potential to be utilised in the structural along with non-structural assembly of numerous components in numerous engineering sectors. This is a result of their advantageous characteristics, including their low cost, biodegradability, non-toxicity, and great strength-to-wt. ratio. The aim of the research is mechanical aspects of PCs reinforced with NFs after one year of water immersion (WI). The Comp.s that were developed were subjected to mechanical characterization (hardness tests) after one year of WI in the current chapter. The Comp.s that were developed were immersed in potable water at room temp. for a period of 12 months. After one year of immersion in water, hardness (shore D) aspects of the samples were assessed and compared to those of the dried specimens. The NF is the sole source of moisture absorption in bio-Comp.s. In this study, laminated Comp.s were developed, with the upper layer composed of epoxy polymer, for bio-Comp.s, as the hardness test is contingent upon the material's upper surface. Consequently, the hardness value (HV) of bio-Comp. specimens has remained nearly unaffected by WI. The minor drop in values may be attributed to the polymer layer's softening.

Keywords: Natural fibers, Hardness tests, Polymer composites, Water immersion

1. Introduction

Polymer Comp.s are frequently employed owing to their substantial attributes, including their low weight (wt.) and great specific strength (Rajeshkumar et al., 2021). A polymer composite (PC) material is formed by impregnating fibres with a polymer matrix (poly-mat), which forms a bond across them (Khan et al., 2021). The matrix material for PCs can be either thermoset polymer (e.g., epoxy, polyester) or thermoplastic polymer (e.g., poly-lactic acid, polyvinyl alcohol) (Atmakuri et al., 2021). Reinforcement may be either natural (fibre, infill, etc.) or synthetic (glass, carbon, aramid, etc.). The Comp. that is developed is referred to as a synthetic fiber-grounded PC when the ploy-mat is reinforced with synthetic fibres (glass, carbon, arami0d, etc.) (Raja et al., 2021). Conversely, the Comp. that is developed is referred to as a NF-grounded Comp. when the reinforcing fibres are natural (excerpted from natural sources like plants, animals, or minerals) (Wong et al., 2021). Biodegradable ploy-mat and synthetic ploy-mat are also subcategories of ploy-mat (Neto et al., 2021). Natural fibres that are reinforced with a synthetic ploy-mat are referred to as partially biodegradable PCs, while those that are reinforced with biodegradable polymer are referred to as fully biodegradable PCs (Godara et al., 2021).

Natural fiber-reinforced PCs can be effectively fabricated utilising all of the processing techniques that are currently employed to create synthetic fiber-grounded PCs, with minimal modifications to the existing technique (Lee et al., 2021).

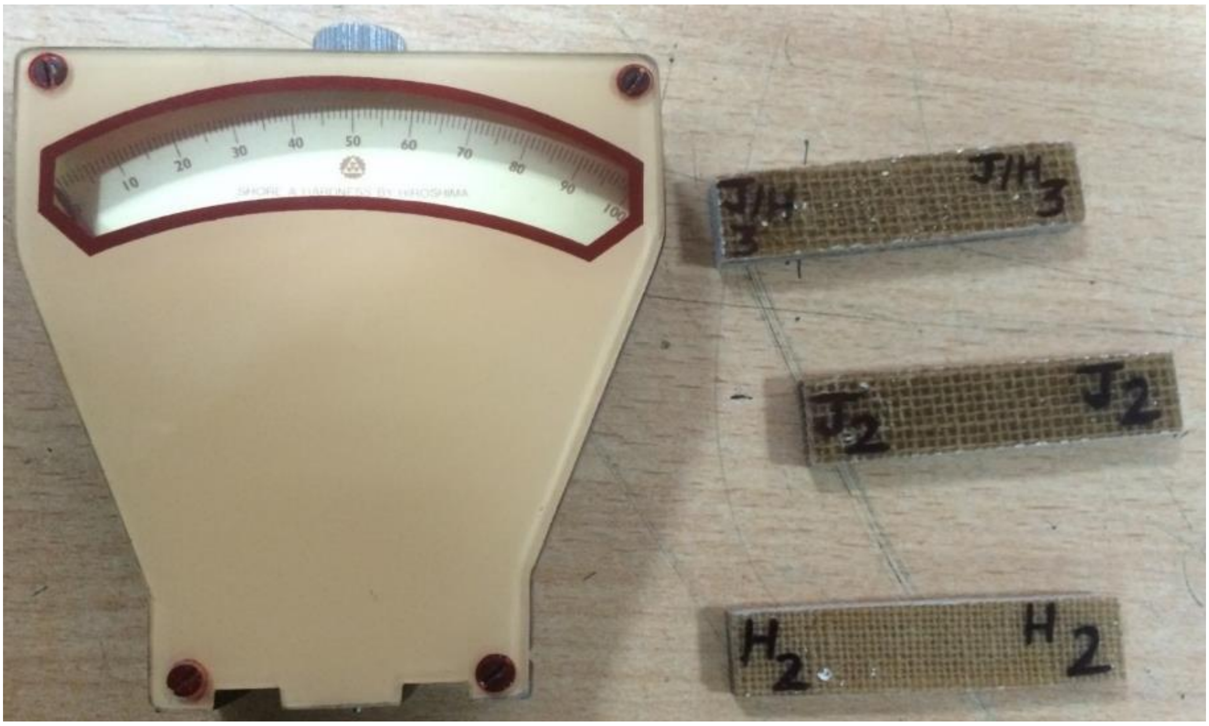
Environmentally favourable, biodegradable, and non-toxic PCs are produced from NFs that are harvested from the cornucopia of nature. Conversely, synthetic fibres are produced through chemical processes that are greatly detrimental to the environment (Gupta et al., 2021). Fiber-reinforced plastics (FRPs) that are composed of synthetic fibres are implemented in a broad array of industries, counting aerospace, automobiles, and construction. This is a result of their multifunctional and distinctive characteristics, including their great specific strength. However, the primary obstacle associated with synthetic FRPs is the non-environmentally favourable processing of synthetic fibres and their decomposition issues. The processing of glass and carbon fibres can lead to severe health risks, and in some cases, the loss of human life (Patel et al., 2024). Attempts to supplant synthetic fibres are made by incorporating plant-grounded fibres as reinforcement in PCs. The mechanical properties (MPs) of plant fibres are comparable to those of glass or carbon fibres, and their densities are lesser. This results in the creation of bio-Comp.s that are lighter in wt. but still possess comparable strength, a concern that is of paramount importance to numerous industries, including the automotive industry. The fuel efficiency and, consequently, the reduction in pollution levels are directly proportional to the lightwt. nature of automobile bodies (Gupta et al., 2021)0000. This investigation looks to probe the mechanical aspects of PCs reinforced with NFs after one year of WI.

2. Material and method

Compact Buying Services, located in Faridabad, India, delivered the jute, hemp, and flax fibres. Composites were manufactured utilising bi-directional woven matting.

Epoxy resin served as the matrix material in this investigation. Shankar Dyes and Chemicals, Delhi-06 (India), acquired epoxy resin and silica release gel.

Hardness is a property that quantifies the resistance delivered against surface indentations. Shore scale durometers are typically employed to evaluate the hardness of polymer-grounded Comp.s. Shore-A and Shore-D are the two varieties of shore instruments that are employed for hardness testing. Soft polymers are typically measured utilising the Shore-A scale, while rigid polymers are measured utilising the Shore-D scale. Indenters of varying sizes and configurations are employed by both instruments. The Shore-D Hardness tester (PSI sale, Noida, India) was employed to quantify the hardness of the Comp. laminates in the current investigation, as illustrated in figure 1. The indenting foot of the Shore-D hardness tester is equipped with a reinforced steel rod with a diameter of 1.1mm-1.4mm, a conical point of 300, and a 0.1mm radius tip.



3. Result and Discussion

Hardness

0

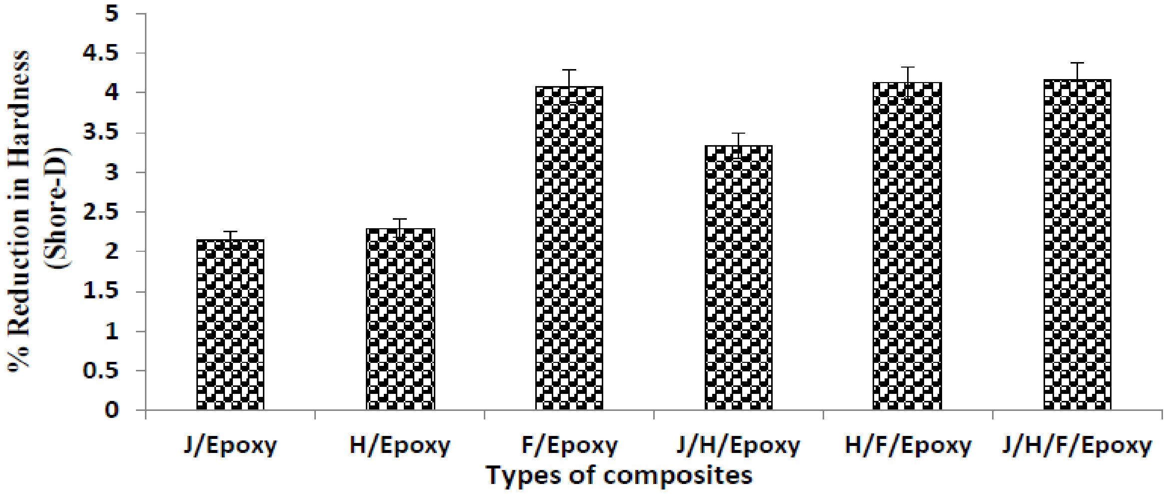


Figure 2 shows the hardness (Shore-D) of water saturated jute or epoxy, hemp or epoxy, flax or epoxy, jute or hemp or epoxy, hemp or flax or epoxy and jute or hemp or flax or

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epoxy Comp.s.

Upon examination of the results, it has been determined that the HV of all water-saturated (WS) specimens has dropped relatively minimally. The WS flax or epoxy Comp. exhibited the max. Shore-D hardness of 00among all the Comp.s that were developed. This was obtained after the Comp. specimen was submerged in water for one year. The HV of the flax or epoxy Comp. specimen was reduced by 4.08% in comparison to the dried flax or epoxy Comp. specimen. The Comp. specimen with WS hemp or flax or epoxy obtained the second max. Shore-D hardness of 93 after one year of WI. This caused a 4.12% drop in hardness likened to the dried hemp or flax or epoxy Comp. specimen. Relative to the dry specimens, the HV of the WS jute or epoxy, and hemp or epoxy, along with jute or hemp or epoxy Comp. specimens was reduced by 2.15%, 2.29%, and 3.33%, respectively. Compared to the desiccated specimen, the Shore-D hardness of the WS jute or hemp or flax or epoxy Comp. specimen was, resulting in a max. reduction of 4.16%. The hydrophobic nature of epoxy polymer may be the cause of the marginal change within the HV of these bio-Comp.s, as it has a propensity to repel water.

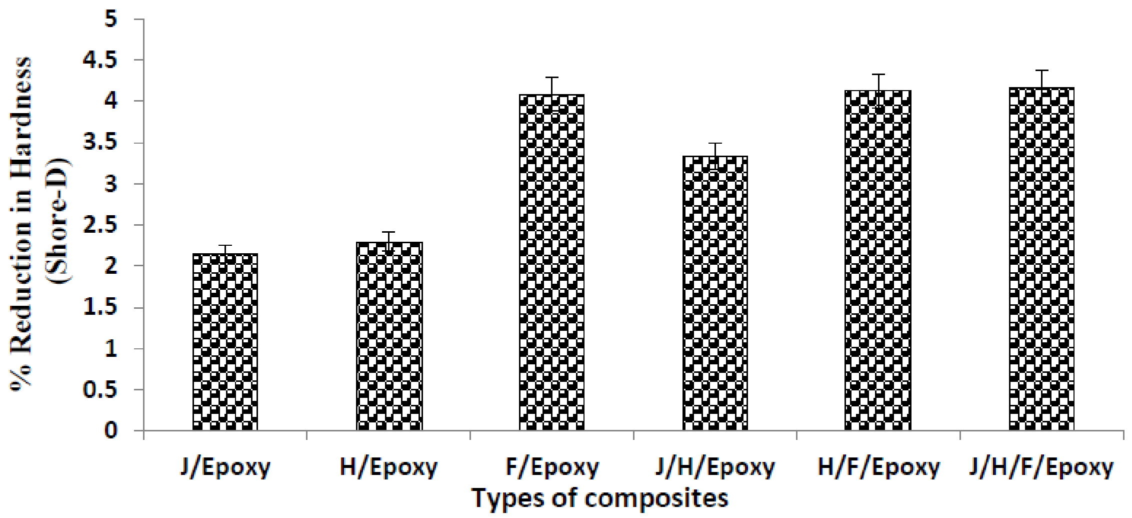

Figure 3. Percentage reduction in Hardness (Shore-D) of Comp.s (J-Jute, H-Hemp, F-Flax)

The HV of the Comp. material that has been developed is influenced by the nature and aspects of the matrix and reinforcement. The HV of Comp. material is significantly influenced by the following variables: interfacial adhesion across fibre and matrix, along with % of fibre loading, and treatment of fibre and matrix, along with hybridization of fibres.

Figures 3 illustrate the % drop in tensile aspects of all Comp.s that were made following one year of immersion in water. The TS of the water-immersed flax or epoxy Comp. has been observed to be minimally reduced (11.27%) in comparison to that of the dried specimen, as illustrated in figure 4.20. The WS flax or epoxy Comp. attained a TS of 41MPa, the second-greatest value among all the Comp.s that were made following water immersion.

4. Conclusion

After one year of water immersion, the Comp. specimen exhibited the greatest Shore-D HV among all other developed Comp.s, which was attributed to the uniform surface and reduced debonding across the fibre and matrix phase. Consequently, flax fibre possesses low WA aspects. The durability of hemp or flax or epoxy along with jute or hemp or flax or epoxy hybrid Comp.s was also improved by the hybridization of flax fibre with jute and hemp fibre.

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