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CONFERENCE PAPER

EFFECT OF CHEMICAL TREATMENT AND FIBER LOADING ON BAUHINIA VAHLII BAST FIBER-REINFORCED ABS COMPOSITES FOR AUTOMOTIVE APPLICATIONS

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Acrylonitrile butadiene styrene, Bauhinia vahlii, chemical treatment, fiber loading, fiber- matrix bonding, mechanical properties, regression curve

Abstract

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Now a days, automobile industries are focusing more on producing lightweight materials for vehicle body sections. Because of their lightweight and environmentally benign character, natural fibers have been the subject of extensive research. In the current study, composites were made by reinforcing treated Bauhinia vahlii bast fiber (BV) fibers with Acrylonitrile butadiene styrene (ABS) thermoplastic polymer to make light-weight automotive parts. Several parameters, including static and dynamic mechanical properties, thermal, and morphological properties, were investigated. To improve compatibility with the ABS matrix, fiber surfaces were treated with various chemicals. Mechanical qualities improved as treated BV fiber loading increased until it reache d its optimum (23 wt%), after which they declined. The maximum mechanical values obtained at optimum fiber loading were 68.94 MPa tensile strength, 7.02 GPa young's modulus, 95.27 MPa flexural strength, and 33.25 kJ/m2 impact strength. TGA, DMA, and SEM were employed for analysis. Overall, the findings indicate that reinforcing the ABS matrix with BV filler significantly improves the properties of the created composite materials.

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Introduction:-

The challenges with using man-made fiber reinforced composites are that they impart qualities to both manufacturing and post-consumer waste goods, resulting in recycled products with unpredictable properties. During the thermal recycling process, the synthetic fibers do not completely burn and remain as solid trash, which must be buried in soil. Various natural fibers like flax, jute or sisal reinforced composite materials plays an important role in reduction of density in automobile parts manufacturing due to its higher specific stiffness and specific tensile strength.

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The focus of automobile industries is to increase fuel efficiency without neglecting or sacrificing the safety which can be achieved by using natural fiber reinforced composite materials for the interiors and exteriors of the car body so that weight reduction can be achieved. Natural fibers that possess better mechanical properties than synthetic fibers favour the industries as well as the researchers because of various applications and advantages in different sectors like textile, aerospace, defense, sports sector and automobile sector.

In this new era of bio composites, various major variants of Mercedes Benz are utilizing natural fiber like jute for their door panels. A reduction of 5% in weight was observed by using polymer composites reinforced with natural fibers in the engines of setra variants. It was observed that natural fiber reinforced polymer composites find wide applications in manufacturing of door lining and panels, interiors of various automobile giants. Cotton fibers and wood fibers are used for sound proofing materials and seat backrest respectively. For seat cushioning of cars, coconut fibers are used. Various researchers have already utilized different natural fibers like hemp, flax jute sisal, kenaf, and ramie which are in use for various sectors like plastic ware, aerospace, and automotive industries. Mechanical, Morphological, Structural, and Dynamic Mechanical Properties of Alkali Treated Ensete Stem Fibers Reinforced Unsaturated Polyester (UP) Composites were investigated by Negawo et al. They came to the conclusion that treated Ensete fibers increased the mechanical, morphological, and dynamic qualities of UP for a variety of designed and high-tech applications. Madhu et al. investigated the physicochemical, thermal, mechanical, and morphological properties of agave americana fiber for composite reinforcement using various chemical treatments. They came to the conclusion that chemical modification techniques applied to natural fiber surfaces allow for the production of superior fibers that can be used to create unique composite materials for lightweight applications. However, it was observed from the literature available on natural fibers that no polymer composites have been prepared using Bauhinia vahlii bast fibers as reinforcement in polymeric matrices. BV belongs to the Caesalpiniaceae family and mostly available in the India, Nepal and Pakistan. It contains anti-inflammatory properties as well as high fiber content. It is proposed that B. vahlii bast fibers (BV) as rein- forcing material can be most suitable for composite preparation for automotive sector uses.

Material and Method:-

The BV stems were collected from various locations in Odisha, Bhubaneswar. The following process was used to remove the fibers from the stem. First, the collected stems were steeped in water for two days to soften the outer bark, allowing for easy removal. The barks were then removed manually with a scalpel. The fibers were extracted manually from the bark, as illustrated in Figure 1. The extracted fibers were then thoroughly rinsed with distilled water to remove any contaminants, and then dried under sunshine for two days to remove moisture from the fibers. The fibers at this stage were referred to as untreated BV fibers.

FIGURE 1. Extraction of B. Vahlii Fibers

Results:-

Mechanical properties of BV fibers: Pre and post treatment

From the results observed that more enhancement of tensile strength of treated samples was found. Benzoylation treated fibers shows the highest tensile strength of 128.56 MPa, whereas, acrylic-acid-treated date palm fibers exhibits 70.27 MPa, benzyl-chloride-treated areca sheath fibers exhibits 115.48 MPa. As benzoylation treated BV fibers reveals better mechanical properties as compared to untreated and other treated fibers, hence, it was selected for fabrication of treated and untreated composites and further testing.

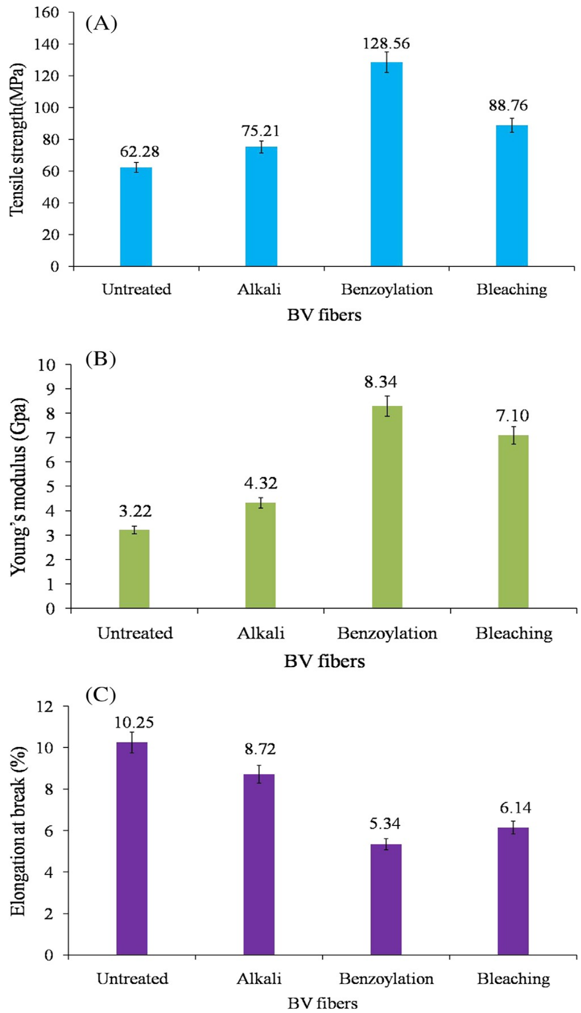

FIGURE 2. Mechanical properties of untreated and treated BV fibers

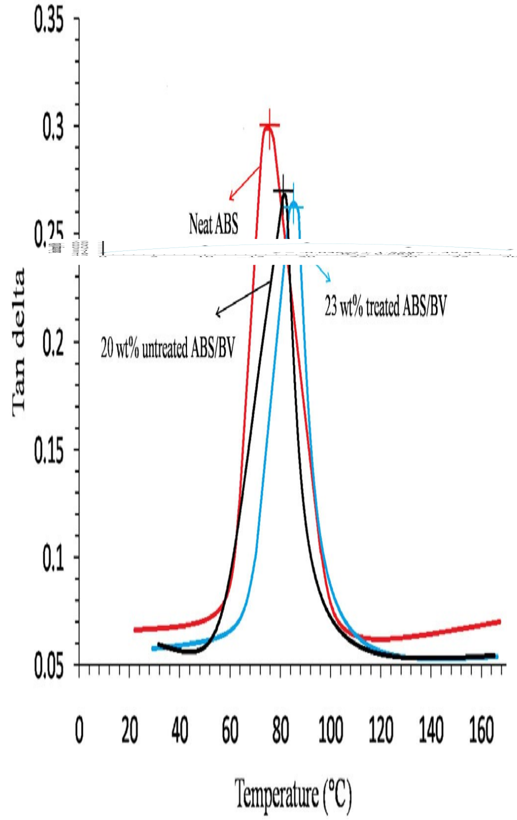

FIGURE 3. Damping Factor

Fourier Transform Infrared (FTIR) Spectroscopy

Bauhinia vahlii fibers were analyzed by FTIR, showing peaks at 3347 cm⁻¹ (O–H), 2920 cm⁻¹ (C–H), 1725 cm⁻¹ (C=O), 1510 cm⁻¹ (C=C), and 1245 cm⁻¹ (C–O). After treatment, peaks related to hemicellulose, lignin, and pectin were reduced or disappeared; notably, the 1725 cm⁻¹ peak vanished and the 1510 cm⁻¹ peak weakened, indicating removal of non-cellulosic components (Maache et al. 2017; Shanmugasundaram, Rajendran, and Ramkumar 2018). Overall, the results confirm effective elimination of amorphous constituents and increased cellulose content (Sepe et al. 2018).

X-ray Diffraction (XRD) Analysis

Bauhinia vahlii fibers were analyzed by XRD to assess crystallinity after chemical treatment. Peaks at 2θ = 16.7°, 22.8°, and 34.7° correspond to the (110), (002), and (004) planes of cellulose I (Dong et al. 2014; French 2014). Increased intensity of the (110) peak and sharpening of the 22.8° peak indicate removal of amorphous components and improved crystallinity. The crystallinity index increased for all treated fibers, with benzoylated fibers showing the highest value (70.10%), followed by alkali, bleaching, and untreated fibers, confirming removal of non-crystalline constituents and better cellulose alignment (Obi Reddy et al. 2013).

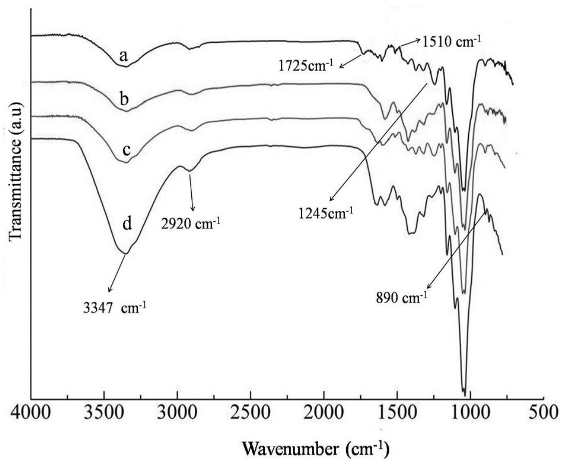

Figure 5. FTIR spectrum of (a) untreated (b) bleaching (c) benzoylation (d) alkali BV fibers.

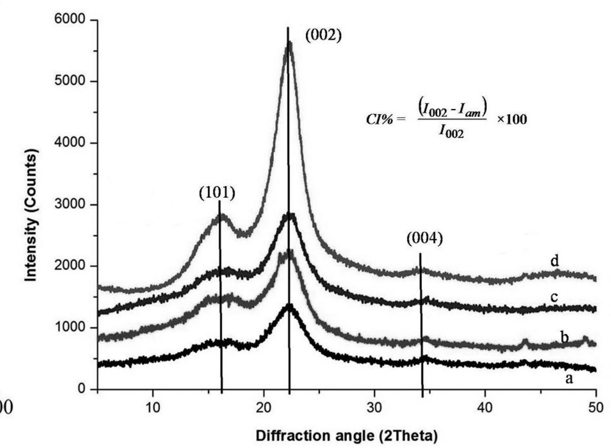

Figure6. XRD patterns of (a) untreated (b) bleaching (c) alkali (d) benzoylation BV fibers.

Thermogravimetric Analysis (TGA)

Bauhinia vahlii fibers showed three-stage degradation: moisture loss (30–140 °C), major decomposition (210–320 °C), and char formation. Untreated fibers had higher initial mass loss due to hydrophilicity, while treated fibers showed reduced loss. Maximum degradation occurred in untreated fibers (~55%), whereas benzoylated fibers

showed delayed degradation and lower mass loss. Treated fibers exhibited improved thermal stability, with degradation temperature increasing from ~345 °C to ~370 °C; alkali-treated fibers showed highest stability (Mayandi et al. 2018; Belouadah, Ati, and Rokbi 2015).

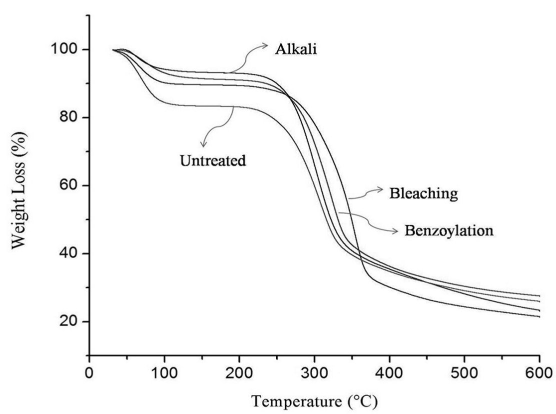

Figure 7. TGA curve for untreated and treated BV fibers.

Scanning Electron Microscope Analysis (SEM)

Figure 4 represents the SEM images of 23 wt% treated and 20 wt% untreated ABS/BV composites. Fractured samples of tensile test were taken for SEM analysis to have an idea of fiber-matrix bonding in the composites. Ones these fibers are treated, lignin and waxy materials are removed from the surface and better bonding is noticed in processed composites.

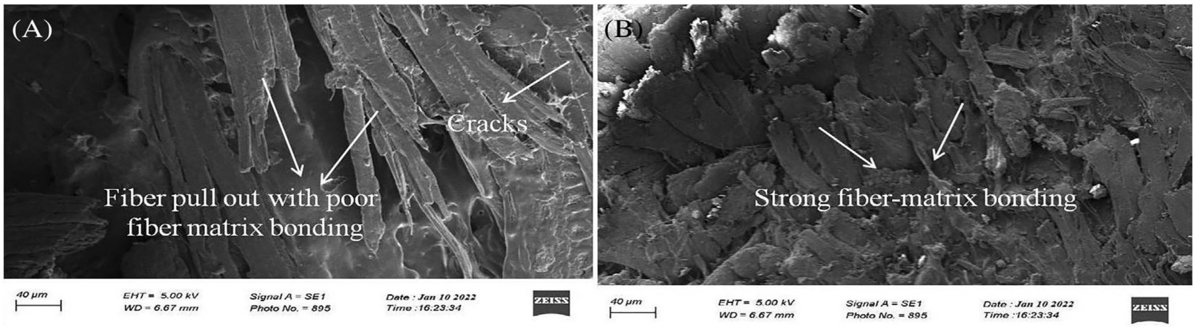

FIGURE 8. SEM image of (A) 20 wt.% untreated ABS/BV composite (B) 23 wt.% treated ABS/BV composite

Conclusions:-

In the current work, an effort was made to produce a new composite with the reinforcement of benzoylation treated B. vahlii bast fiber (BV) fibers and ABS thermoplastic polymer for automobile body component use. When compared to ABS composites, the introduction of BV fibers, particularly those that have been benzoylated, dramatically increases the composite's strength. It was discovered that 23 wt% was the optimum value of BV fiber, which gives a maximum mechanical property of 68.94 MPa tensile strength, 7.02 GPa Young's modulus, and 95.27 MPa flexural strength, by fitting a second-degree polynomial curve with regression coefficient of 0.984 in tensile test data of various wt% of fiber loading. These qualities are far superior to those achieved with other treated composites. SEM examination revealed improved fiber-matrix bonding. The TGA results revealed that the composite was thermally stable when compared to other manufactured composites. Again, DMA revealed that the treated fiber composite had good dynamic mechanical characteristics. According to the current study, BV/ABS composites have a lot of potential in industrial lightweight engineering and outdoor applications, such as building panels and automotive elements like dashboards and door panels.

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