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Characterization of Polymer Composite Reinforced with *Desmostachya bipinnata* Natural Fibers of 600 Micron Size

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Abstract

Desmostachya bipinnata (Dharbe grass) has been used as a sacred plant in many of the rituals in India. A composite was prepared using hand layup using Desmostachya bipinnata particle with mesh size of 600microns. The specimens were evaluated for tensile, electromagnetic shielding effectiveness. The specimens were also investigated using scanning electron microscope. It is observed that the composite yielded better results in terms of tensile strength, but the results obtained for electromagnetic shielding effectiveness were not encouraging. The insufficient electromagnetic shielding effectiveness might be attributed to the size, shape, or distribution of the Desmostachya bipinnata particles within the composite.

Keywords: *Desmostachya bipinnata, Electromagnetic Shielding, Tensile*

1.0 Introduction

In today's world, there is a growing emphasis on environmental sustainability, and natural fibers have emerged as a viable alternative to inorganic fillers in composites. These fibers not only fulfil the need for sustainable materials but also offer several advantages[1].

Natural fibers are abundantly available. They can be sourced from various renewable resources such as plants, animals, and even minerals. This ensures a consistent and reliable supply of these fibers, reducing the strain on natural resources. Natural fibers are often more affordable compared to inorganic fillers. The production costs of natural fibers are generally lower, making them a cost-effective option for composite manufacturing. This affordability contributes to their widespread use and accessibility in various industries. Natural composites are generally more cost-effective than MMCs. Manufacturing MMCs requires more complex processing techniques compared to natural composites. The production methods for MMCs involve additional steps such as melting, casting, and solid-state diffusion bonding, which can increase the complexity and cost of production[2-3]. The raw materials used in natural composites, such as wood fibers or agricultural waste, are often readily available and inexpensive, reducing the overall production costs. Natural fibers are easily recyclable. Unlike synthetic fibers, which often pose challenges in terms of recycling and disposal, natural fibers can be readily recycled or composted. This recyclability reduces the environmental impact associated with their use and promotes a circular economy approach. Furthermore, natural fibers are biodegradable[4]. They break down naturally over time, returning to the environment without leaving behind harmful residues.

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This property is particularly advantageous in applications where end-of-life disposal is a concern, as it minimizes waste and environmental pollution.

In addition to their environmental benefits, natural fibers also offer specific advantages in composite materials. They possess favourable mechanical properties, including high strength-to-weight ratio and good impact resistance. These properties make them suitable for various applications, such as automotive components, construction materials, packaging, and consumer goods. Moreover, natural fibers can enhance the sustainability of composites by reducing their overall carbon footprint[5]. By replacing inorganic fillers, which often require energy-intensive production processes, with natural fibers, the environmental impact of composite materials can be significantly reduced.

Overall, the utilization of natural fibers in composites aligns with the goals of environmental sustainability. Their abundance, affordability, recyclability, and biodegradability make them a promising alternative to inorganic fillers. By incorporating natural fibers into composite materials, we can contribute to a greener and more sustainable future.

In this work we have considered *Desmostachya Bipinnata* (DB) a natural grass which in kannada language known as Dharbe hullu (ದರ್ಬೆ ಹುಲ್ಲು). This grass is considered as one of the most sacred one among several, religions across the world. Considering this for producing composite, nil work has been carried out. Here we have tried to develop the composite and tested it for tensile, electromagnetic interference.

Testing the developed composite for tensile strength and Electromagnetic Interference (EMI) performance demonstrates the practical application and potential of this material. Tensile strength evaluation provides insights into the mechanical properties of the composite, which is crucial for determining its structural integrity and suitability for various load-bearing applications. On the other hand, studying the EMI characteristics of the composite is significant in the context of shielding electromagnetic waves. This property is highly valuable in industries where electromagnetic interference can affect the performance of electronic devices or sensitive equipment. By conducting these tests, we are expanding our understanding of the composite's properties and its potential applicability in relevant fields. Furthermore, it opens avenues for further research and potential applications in areas such as automotive, aerospace, electronics, and renewable energy. This work holds promise in terms of sustainable material development and aligns with the global emphasis on eco-friendly solutions[6]. Utilizing a natural grass like *Desmostachya bipinnata* not only benefits the environment but also supports the conservation of cultural and traditional values associated with the plant.

2.0 Methodology

The *Desmostachya bipinnata* composite was prepared using hand layup technique. The epoxy used is L-12 resin and hardener K-6. In this process the resin, fibre and hardener are coalesced in the ratio 100:20:20. Before making the composite the DB grass is blended for fine powder and sieved for 600 microns.

To prepare the DB composite first the mold or tool is prepared by cleaning and applying a release agent to prevent the composite part from sticking to the mold[7]. Then the mixture of resin hardener and fibre is poured into the mold. While pouring care is taken to remove any air pockets or voids that could weaken the composite part. The composite is left to cure for a specific period of time, during which the resin hardens and bonds the reinforcement materials together. Once the composite part is fully cured, it is removed from the mold or tool, and any excess material is trimmed or sanded off.

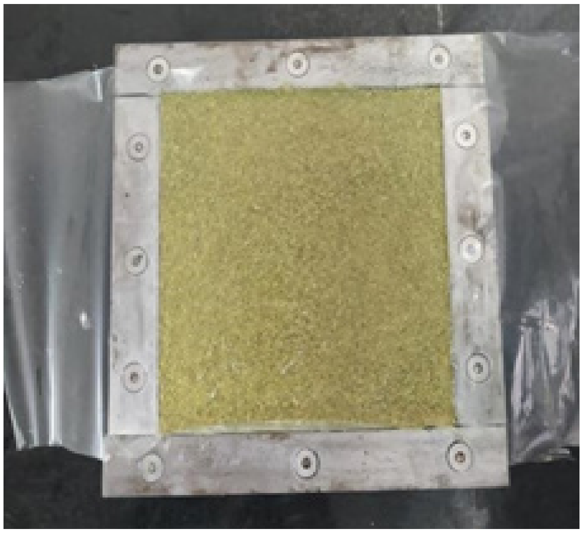

Figure 1. Hand layup process of DB Composite.

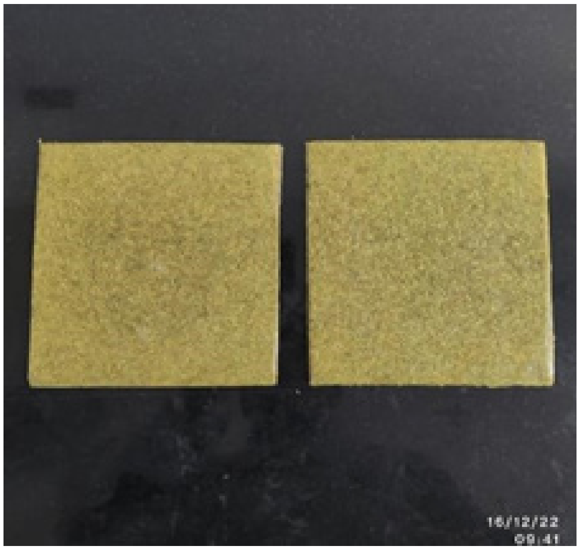

Figure 2. Final DB Composite

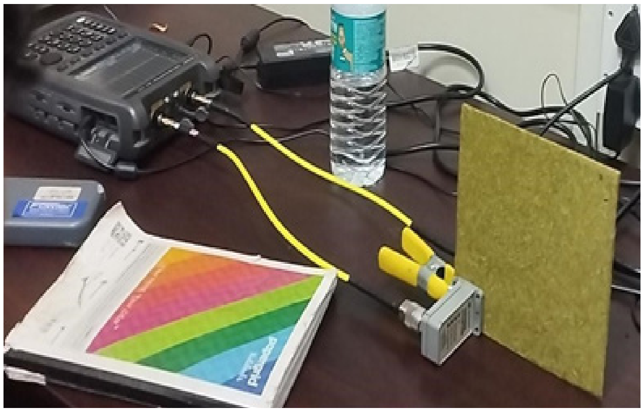

Figure 3. Electromagnetic shielding effectiveness experimental setup

For tensile test ASTM D3039 standards were used. The specimens were prepared as per this standard and test was conducted using 2T Tensometer. The electromagnetic shielding effectiveness of the samples was experimentally measured via a far-field electromagnetic plane wave using the ASTM D4935-18 standard (Figure 3)[8]. The setup consisted of a sample holder with its input and output connected to a network analyser. The measured sample was in the shape of a square of 10cm side.

The Free Space Transmission Line (FSTL) method for EMI testing involves the use of specialized test equipment to generate and measure electromagnetic fields in a free-space environment. Free-space measurement techniques have the benefit of obtaining reflection and transmission coefficients without making physical contact with the sample, making them ideal for thin, flat materials.

3.0 Result and Discussion

3.1 Tensile Test

The tensile test report provides valuable insights into the mechanical behaviour of the composite material. The peak stress of 20.79 MPa indicates its ability to withstand high levels of external forces before failure. The yield stress

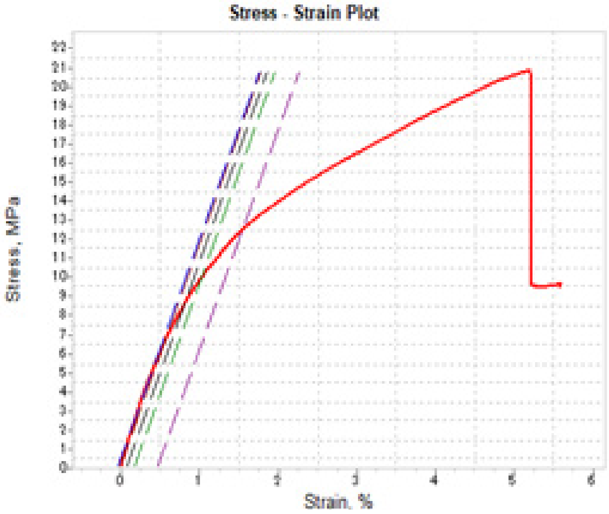

Figure 4. Stress Strain Plot of DB Composite.

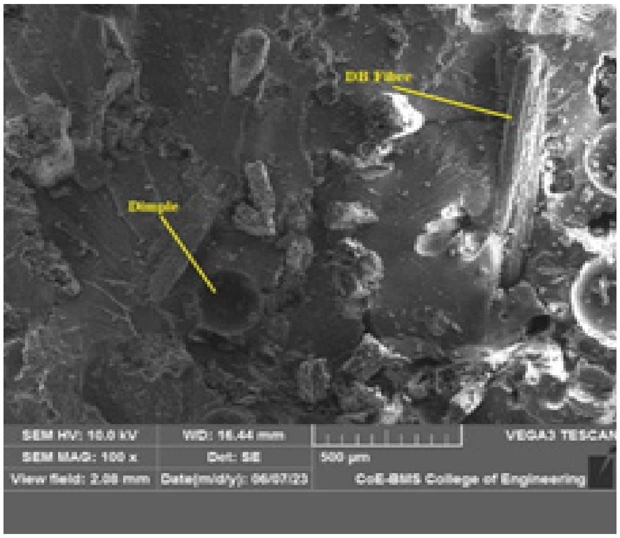

Figure 5. SEM image of the broken surface.

values, such as the 0.2% offset yield stress of 10.006 MPa, demonstrate the material's ability to exhibit significant plastic deformation without fracturing.

The modulus value of 1.15 GPa reflects the composite's stiffness, indicating its potential for structural applications where rigidity is important. The strain hardening exponent and coefficient values suggest a moderate strain hardening effect, which can enhance the material's strength during plastic deformation. The elongation at break values highlights its ability to undergo significant elongation before failure, which is crucial in applications requiring flexibility and ductility.

Furthermore, the energy absorption characteristics of the composite, such as the total energy of 3.46 J and energy under the plastic region of 3.09 J, demonstrate its ability to dissipate energy effectively, indicating potential use in impact-resistant applications[9]. The provided data on load and extension relationships, as well as strain at the maximum load, allow for a comprehensive understanding of the material's behaviour under specific conditions.

The SEM image exclusively captures a fracture surface characterized by dimples ranging from 200 to 400 microns in size. Notably, the dimples exhibit a notably rounded shape, as depicted in Figure 5. As the dimples increase in size, their tendency towards elongation and coalescence becomes more apparent. Although the formation of large dimples cannot be attributed solely to the presence of large inclusions, their presence in conjunction with slender connections between the inclusions suggests that plastic deformations significantly contribute to the merging of neighbouring pores during ductile fracture.

3.2 EM Shielding Effectiveness

The experimental test results indicate a lack of substantial capability in impeding electromagnetic radiation, as illustrated in Figure 6. It is understood that the presence of the resin hampers the inter-fiber contact, thereby resulting in composites with higher fiber volume fractions. This, in turn, ensures enhanced continuity of the conductive filler throughout the material's length and thickness[10]. Consequently, a thicker composite with a higher fiber content could potentially offer improved protection against electromagnetic radiation. This suggests that shielding effectiveness is not solely determined by material conductivity, but also relies on factors such as power dissipation across the thickness and power reflection at various interfaces[11].

4.0 Conclusion

An attempt has been to develop the DB composites and an effort has been to carry out initial investigation on the same. The conclusion which can be drawn from the results are:

- The tensile results are much encouraging which resulted in a modulus value of 1.152GPa which is appreciable.

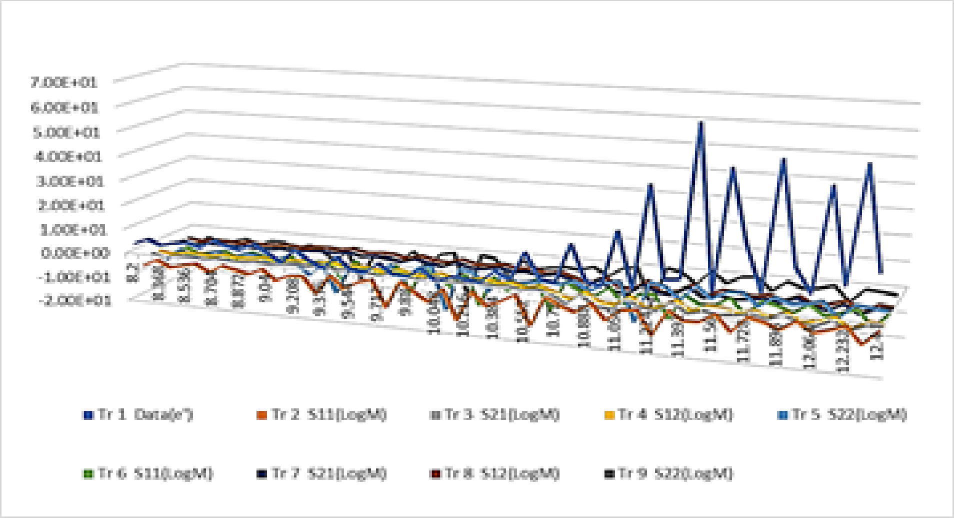

Figure 6. EM Shielding results for DB composite.

- SEM analysis show plastic deformations significantly contribute to the merging of neighbouring pores during ductile fracture.
- As EMI shielding is not so effective, Further research and experimentation may be necessary to optimize the composite's electromagnetic shielding effectiveness. Modifying the size, concentration, as well as exploring different matrix materials or incorporating additional shielding agents, could potentially improve the composite's performance in this regard.

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