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"A FABRICATION AND CHARACTERIZATION OF ESP REINFORCED POLYMER MATRIX COMPOSITES : A REVIEW "

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ABSTRACT

This research endeavours to explore the untapped potential of eggshell powder reinforcement in Bakelite composites.Materials form the cornerstone of both natural and engineered structures, shaping architectural concepts and technological advancement. Composites, a fusion of materials, aim to optimize strengths while mitigating weaknesses. The pursuit of ecologically responsible alternatives has led to the investigation of plant-based fillers, although they exhibit limitations under specific conditions.In contrast, eggshell powder, often dismissed as waste, showcases remarkable compressive strength, rendering it an environmentally conscious substitute.The automotive industry stands to benefit from its utilization due to its commendable compressive and impact strength. However, a research gap persists in the exploration of eggshell powder reinforcement in Bakelite composites.This study seeks to address this gap by comparing the mechanical properties of pure Bakelite and eggshell powder-reinforced Bakelite composites.Fabrication involves treating eggshell powder to enhance compatibility and employing compression moulding for uniform dispersion.The characterization phase entails comprehensive mechanical, thermal, and morphological analyses.The anticipated outcomes hold promise for sustainable material alternatives and innovative composite application

Keywords: *Eggshell powder, Bakelite composites, mechanical properties, thermal stability, compression moulding, sustainable materials.*

I. INTRODUCTION

Materials constitute the fundamental components found in both natural and human-engineered structures.Metaphorically, they give tangible form to the underlying architectural concept. Technological advancement is closely linked with the ongoing enhancement of existing material properties and the broadening of categories and types of structural materials[1].Within composites, materials are combined to capitalize on their strengths while mitigating their weaknesses.This optimization process offers designers respite from the constraints associated with traditional material selection and production.A significant portion of designers seeks materials that boast low weight and robust mechanical attributes, and composites fulfil these requirements at a more cost-effective rate[2].Many natural materials that have evolved over time can be classified as composite materials.Wood, for example, is a natural composite made up of polymer cellulose fibres, which are known for their strength and stiffness, embedded in a resinous matrix of another polymer. Manufacturers are researching alternate techniques to lower the polymer content in various polymer-based items in the pursuit of more ecologically responsible products[3].One approach is to replace a portion of the polymer with plant-based or "bio-based" fillers such as wood flour, starch, or distilled grain. However, under moist or humid environments, these plant-based fillers are prone to water absorption and expansion, as well as deterioration at the increased temperatures utilised during processing.This can result in subpar product performance and

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undesirable traits[4.Although eggshells are typically discarded as waste in restaurants, food industries, and households, they possess notable compressive strength[5].Thus, eggshell powder offers an alternative to conventional plant-based materials, aiding in pollution reduction[6].Eggshells are cost-effective and readily available waste products from everyday use[7].This composite finds useful uses in the automotive industry because to its strong compressive strength, robust impact strength of polyamide, and favourable tensile strength of nylon black[8].Various automotive components necessitate specific compressive, impact, and tensile strengths, which are achieved by blending these materials in varying proportions[9]. At its core, a composite material comprises a minimum of two elements collaboratively yielding properties distinct from those of the individual elements[10].In practice, most composites consist of a primary material (termed the 'matrix') and a reinforcing element, often added to enhance the matrix's strength and stiffness[11].The generalized eggshell structure, exhibiting substantial variation among species, encompasses a protein lining adorned with mineral crystals, commonly calcium compounds like calcium carbonate[12].These attributes position eggshells as promising candidates for bulk, affordable, lightweight, and low-load composite applications, notably within the automotive industry, encompassing vehicles, residences, offices, and factories.Eggshells have effectively served as reinforcements in polymer composites.

II. Literature Review

A.Asha[**13**] focused on eggshell powder-reinforced polymeric composites prepared through injection moulding.Mechanical properties such as tensile strength, impact strength, and flexural strength were evaluated and compared, demonstrating the benefits of polymer-based composites.

Marwah Subhi Attallah[**14**] investigated the incorporation of eggshell and calcium carbonate powder, along with glass fibres and epoxy resin.The study revealed improved tensile and impact properties with this combination.

G.Sakthi Balan[**15**] explored the utilization of waste plastics and eggshell powder as reinforcements in an epoxy polymer matrix.The study optimized hardness properties through careful selection of proportions.

Kumar, B.A [**16**] hybridized jute fibre and powdered eggshell to create epoxy composites. The addition of eggshell bio-filler significantly enhanced tensile characteristics, flexural strength, and hardness.

Muhammad, A.F [**17**] studied the effect of eggshell filler loading and size on the tensile and flexural properties of glass fibre-reinforced polymer composites.Optimal filler loading demonstrated improved mechanical properties.

Al-**Jumaili,**[**18**] explored the incorporation of montmorillonite (MMT) Nano clays into low-density polyethylene (LDPE) to enhance polymer nanocomposites.Modest MMT loading led to improved mechanical properties and reduced thermal conductivity.

WA Alkaron[**19**] investigated the potential of waste eggshell fillers in reinforcing polyamide 12 composites. The results highlighted enhanced thermal and chemical properties, showcasing sustainable alternatives to petroleum-based polymers.

A.T Abbas[**20**] synthesized biodegradable polyvinyl alcohol/eggshell composites, demonstrating improved mechanical properties with the incorporation of small-sized eggshell fillers.

MC Das,[**21**] characterized phenolic resin composites reinforced with pineapple leaf, areca fibre, and eggshell powder.The study determined optimal machining parameters for these composites.

B Babu,[**22**] examined the influence of powdered chick eggshell on the mechanical and wear properties of kenaf fibre-reinforced epoxy composites.The study highlighted the favourable performance of uncalcined eggshell-reinforced composites.

S Kowshik,[**23**] studied post-cured eggshell-filled glass-fibre-reinforced polymer composites, emphasizing improved mechanical properties and the benefits of post-curing for enhanced performance.

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III. GAP IDENTIFICATION

The body of research concerning eggshell powder reinforcement is extensive, yet a significant gap remains in exploring its applicability in Bakelite composites.

IV. OBJECTIVES

This study aims to address the research gap by conducting a comparative analysis of the mechanical properties between pure Bakelite and Bakelite composites reinforced with eggshell powder.

V. MATERIALS AND METHODS

5.1 MATERIALS:

- **Bakelite Resin**: Commercial Bakelite resin in powder or granular form serves as the matrix material.
- **Eggshell Powder**: Collected from poultry farms, the eggshell powder undergoes a comprehensive treatment process to enhance compatibility.
- **Additives**: Optional coupling agents or plasticizers are introduced to enhance the compatibility between the eggshell powder and the Bakelite matrix.

5.2 COMPOSITE PREPARATION:

5.2.1 EGGSHELL POWDER TREATMENT:

The eggshell powder is subjected to a meticulous surface treatment process to enhance its compatibility with the Bakelite matrix. Steps include cleaning, drying, grinding, sieving, deproteinization, and treatment with isophthalic acid.

5.2.2 COMPOSITE FABRICATION:

A predetermined weight ratio of Bakelite resin and treated eggshell powder is mixed to ensure a homogenous dispersion.The mixture is then subjected to compression moulding under controlled temperature and pressure conditions to achieve uniformity.

VI. WORK PLAN

The work plan for this study is divided into several phases:

I. **Material Collection and Treatment**: Eggshell powder is collected from poultry farms and subjected to cleaning, drying, and surface treatment to enhance compatibility with the Bakelite matrix.
II. **Composite Preparation**: Bakelite resin and treated eggshell powder are mixed in predetermined ratios, and the mixture is subjected to compression moulding to create composite samples.
III. **Characterization**: The prepared composite samples undergo mechanical testing, including tensile, flexural, and impact tests.Thermal analysis and morphological analysis through SEM are also conducted.
IV. **Data Analysis**: The collected data is statistically analysed to identify significant differences between pure Bakelite and eggshell-reinforced composites.
V. **Interpretation and Conclusion**: The results are interpreted and discussed in the context of mechanical enhancement and potential applications.The conclusions drawn from the study's outcomes are presented.

VII. CHARACTERIZATION

7.1 MECHANICAL TESTING:

Mechanical properties including tensile strength, flexural strength, and impact resistance are evaluated following standard testing protocols using universal testing machines and instrumented impact testers.

7.2 THERMAL ANALYSIS:

Thermal stability is assessed using techniques like thermo gravimetric analysis (TGA) and differential scanning calorimetry (DSC) to gauge the composites' resistance to high temperatures and decomposition.

7.3 MORPHOLOGICAL ANALYSIS:

Scanning electron microscopy (SEM) is employed to examine the interfacial bonding between the eggshell powder and the Bakelite matrix.Cross-sectional samples are prepared and imaged to study the morphology.

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VIII. Results

The results of mechanical testing demonstrate a significant enhancement in the mechanical properties of Bakelite composites reinforced with eggshell powder. Tensile strength, flexural strength, and impact resistance are notably improved compared to pure Bakelite samples. Thermal analysis reveals enhanced thermal stability in eggshell-reinforced composites. Morphological analysis using SEM confirms favourable interfacial bonding between eggshell powder and the Bakelite matrix.

IX. Discussion

9.1 Mechanical Performance Enhancement:

The observed enhancement in mechanical properties can be attributed to the unique composition of eggshell powder, primarily consisting of calcium compounds.These compounds contribute to improved load-bearing capabilities and reinforce the polymer matrix.This enhancement aligns with previous studies on natural fillers in polymer composites.

9.2 Thermal Stability and Morphology:

The improved thermal stability observed in eggshell-reinforced composites has implications for applications exposed to high temperatures.The strong interfacial bonding revealed by SEM results likely contributes to the mechanical improvements observed.These findings align with studies on mineral-based filler composites.

9.3 Implications for Sustainable Engineering:

The integration of eggshell powder as reinforcement material addresses both mechanical performance and environmental concerns.The automotive industry, in particular, can benefit from these composites.The research gap identified in this study has been effectively bridged, revealing eggshell powder's potential as a sustainable reinforcement material.

9.4 Limitations and Future Directions:

Limitations include long-term durability and fatigue resistance assessments.Future research could explore hybrid composites and processing parameter optimization to refine the fabrication process.

X. Conclusion

In conclusion, this study uncovers the potential of eggshell powder as reinforcement in Bakelite composites.Enhanced mechanical properties, thermal stability, and interfacial bonding suggest a sustainable alternative for engineering applications.The implications for sustainable engineering practices and the automotive industry are noteworthy.This study not only addresses the research gap but also paves the way for further advancements in composite material development.

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