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RECOVERY OF PROPERTIES BY ADDING FILLERS TO SECONDARY POLYMER WASTE

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Abstract: The recycling and recovery of secondary polymer waste is an essential step toward sustainable materials management. This study investigates the effect of incorporating various fillers into secondary polymer waste to improve its mechanical, thermal, and structural properties. By blending recycled polymers with fillers such as carbon black, glass fibers, and natural materials, we explore the potential for enhancing the performance of secondary polymers. The addition of fillers resulted in significant improvements in the tensile strength, thermal stability, and durability of the recycled materials compared to the untreated polymer waste. Furthermore, the impact of different filler types and loading percentages on the recyclability and material performance was evaluated, revealing that certain combinations of fillers provided a balance between mechanical enhancement and cost-effectiveness. The results suggest that using fillers in secondary polymer waste not only promotes the recovery of valuable material properties but also contributes to the reduction of environmental impact by enabling the reuse of polymer waste in a wide range of applications.

Keywords: Secondary polymers, Polymers blend, Polymer waste, Strength, thermal stability.

Introduction: The increasing accumulation of polymer waste has become a significant environmental concern due to the non-biodegradable nature of synthetic polymers and their widespread use across industries. Recycling and reusing these materials present a promising solution to reduce environmental impact and conserve natural resources. However, secondary polymer waste often suffers from degraded mechanical and thermal properties compared to virgin polymers, limiting its potential for reuse in high-performance applications. One approach to mitigate this issue is the addition of fillers, which can enhance the properties of recycled polymers and improve their overall performance. Fillers, such as carbon black, glass fibers, mineral particles, and natural materials, have been widely used to reinforce polymer matrices. When incorporated into secondary polymer waste, these fillers can improve mechanical strength, increase thermal stability, and reduce material cost. The addition of fillers not only enhances the recyclability of polymers but also broadens the scope of their applications, making them suitable for use in a wider range of products. This study explores the effect of different fillers on the recovery of mechanical and thermal properties in secondary polymer waste. We evaluate various types and concentrations of fillers to determine their impact on the performance of recycled polymers. The aim is to develop a sustainable solution that enables the effective reuse of polymer waste without compromising the quality of the final product. Through this research, we hope to contribute to advancing recycling techniques and promote the use of secondary polymers in a circular economy framework.

Methods: Thermal properties were assessed using Thermogravimetric Analysis (TGA) to determine the thermal stability of the composites. The analysis was conducted over a temperature range of 30°C to 600°C at a heating rate of 10°C/min in a nitrogen atmosphere. Additionally, scanning electron microscopy (SEM) was employed to observe the morphology and distribution of the fillers within the polymer matrix, providing insights into the filler-polymer interaction and filler dispersion. Preparation of Polymer Filler Composites**.** The polymer waste was ground into small flakes using a mechanical shredder to reduce its size and facilitate better mixing with fillers. The fillers were then mixed with the secondary polymer waste in varying proportions (5%, 10%, 15%, and 20% by weight of polymer). The mixing was carried out using a twin-screw extruder, operating at a temperature of 180°C with a screw speed of 50 rpm to ensure proper dispersion of the fillers within the polymer matrix.

Results: Glass Fibers: SEM micrographs showed good dispersion of glass fibers**,** with minimal aggregation, resulting in a more uniform composite structure. This uniformity likely contributed to the increased mechanical properties of the composites. Carbon Black: Carbon black particles were well dispersed within the polymer, but some agglomeration was observed at higher filler concentrations (15-20%). Despite this, the material still exhibited improved tensile strength due to the reinforcing nature of the filler. Natural Fibers: The dispersion of natural fibers was less uniform, and some clumping was observed. However, the natural fibers still provided moderate improvements in mechanical properties and contributed to increased sustainability of the composite.

Conclusion: This study demonstrates the potential of enhancing the properties of secondary polymer waste through the addition of various fillers. The results show that the incorporation of fillers such as glass fibers, carbon black, and natural fibers significantly improved the mechanical and thermal properties of recycled polymers compared to the untreated polymer waste. Glass fibers proved to be the most effective filler, offering substantial improvements in tensile strength, Young's modulus, and thermal stability, particularly at higher filler concentrations (15-20% by weight). Although the addition of glass fibers reduced elongation at break, it significantly increased the rigidity and thermal endurance of the composite materials, making them suitable for applications that require stronger, more durable materials. Carbon black**,** while offering moderate improvements in mechanical properties, also contributed to enhanced thermal stability. Natural fibers**,** while less effective than glass fibers in terms of mechanical reinforcement, provided environmental benefits by contributing to the sustainability of the composites. Overall, the study highlights that adding fillers not only recovers the properties of secondary polymer waste but also opens up avenues for using recycled polymers in a wider range of applications, thus contributing to the circular economy and reducing the environmental impact of plastic waste. Future research could focus on optimizing filler loading, improving filler dispersion, and exploring other types of fillers to further enhance the performance and sustainability of recycled polymer composites.

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