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IMPROVING SOME PROPERTIES BY ADDING METAL POWDERS TO THE POLYMER COMPOSITION

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Abstract: The incorporation of metal powders into polymer matrices has gained significant attention for enhancing the mechanical, thermal, and electrical properties of polymer composites. This study investigates the effects of adding various metal powders, including aluminum, copper, and stainless steel, to polymer compositions. The resulting composites were characterized in terms of their thermal conductivity, mechanical strength, electrical conductivity, and morphology. Experimental results demonstrate that the inclusion of metal powders leads to a notable improvement in the thermal and electrical properties of the polymer, with the metal content providing enhanced heat dissipation and conductivity. Additionally, the mechanical properties such as tensile strength and stiffness were significantly improved, depending on the type and concentration of metal powder used. These findings suggest that metal-filled polymer composites can offer advanced performance for applications in industries such as electronics, automotive, and aerospace, where high thermal and electrical conductivity, as well as enhanced mechanical strength, are required [1].

Keywords: Aluminum Powder, Copper Powder, Stainless Steel Powder, Polypropylene (PP), Polyethylene (PE), Polyamide (PA).

INTRODUCTION: Polymers are widely utilized in various industries due to their versatility, low cost, and ease of processing. However, their inherent limitations in properties such as thermal conductivity, mechanical strength, and electrical conductivity often restrict their performance in specialized applications. To overcome these limitations, there has been increasing interest in reinforcing polymers with metal powders to enhance their functional characteristics. Metal powders, when incorporated into polymer matrices, can significantly improve the composite's thermal and electrical conductivities, mechanical strength, and overall durability. The addition of metal powders, such as aluminum, copper, and stainless steel, to polymers creates a synergy between the distinct properties of the metals and the flexibility of the polymer base. The specific properties achieved depend on factors such as the type of metal powder, concentration, particle size, and distribution within the polymer matrix. For example, aluminum and copper powders are particularly effective in increasing thermal conductivity, while stainless steel can enhance the mechanical strength and structural integrity of the composite.This research aims to explore the effects of different metal powders on the properties of polymer composites, focusing on improvements in thermal management, mechanical performance, and electrical behavior. Understanding these interactions will help design advanced materials with tailored properties for applications in electronics, automotive, aerospace, and other industries where high-performance materials are crucial [2].

Material	Type of Material	Main Chemical Components
Aluminum Powder	Metal Powder	Al (Aluminum)
Copper Powder	Metal Powder	Cu (Copper)
Stainless Steel Powder	Metal Powder	Fe (Iron), Cr (Chromium), Ni (Nickel), C (Carbon)
Polypropylene (PP)	Polymer	C_3H_6 (Monomer Unit: Propylene)
Polyethylene (PE)	Polymer	C_2H_4 (Monomer Unit: Ethylene)
Polyamide (PA)	Polymer	($C_6H_{11}NO$) (Monomer Unit: Caprolactam)
Epoxy Resin	Polymer	($C_{21}H_{30}O_7$) (Epoxide group)

Table 1: Chemical Composition of Metal Powders and Polymers Used in the Study

METHODS: In this study, commercially available polymer matrices and metal powders were used. The polymers selected were polypropylene (PP), polyethylene (PE), and epoxy resin (EP). The metal powders used for reinforcement were aluminum (Al), copper (Cu), and stainless steel (SS) with average particle sizes of 50 µm, 30 µm, and 60 µm, respectively. The polymer and metal powder materials were sourced from established suppliers and were used without further purification [3].

Preparation of Polymer-Metal Composite Materials
The polymer-metal composites were prepared using a melt blending method for thermoplastics (PP and PE) and a solution casting method for the thermoset (epoxy resin). The metal powders were added in varying weight fractions (5%, 10%, 15%, and 20%) to the polymer matrix [4].

RESULTS: Thermal Conductivity.The thermal conductivity of the polymer-metal composites showed a significant increase with the addition of metal powders. For polypropylene (PP), the thermal conductivity increased from 0.22 W/m·K (pure PP) to 0.45 W/m·K when 20% aluminum powder (Al) was added. Similarly, polyethylene (PE) exhibited an increase from 0.33 W/m·K to 0.58 W/m·K at 20% copper powder (Cu). Epoxy resin displayed a slight increase in thermal conductivity, from 0.27 W/m·K to 0.41 W/m·K when 15% stainless steel powder (SS) was used. The highest improvement in thermal conductivity was observed with aluminum powder in the PP matrix, while copper powder in PE showed moderate enhancement [5,6,7].

Thermal Stability. Thermogravimetric Analysis (TGA) indicated that the presence of metal powders improved the thermal stability of the composites. For PP composites, the onset degradation temperature increased from 330°C (pure PP) to 350°C at 20% Al. PE composites exhibited similar trends, with the degradation temperature increasing from 380°C (pure PE) to 400°C at 20% Cu. Epoxy composites showed the greatest improvement, with a shift in degradation temperature from 450°C (pure epoxy) to 470°C with 15% SS [8].

CONCLUSION: In this study, the incorporation of metal powders (aluminum, copper, and stainless steel) into polymer matrices (polypropylene, polyethylene, and epoxy resin) significantly enhanced the thermal, mechanical, and electrical properties of the composites. The results demonstrated that the addition of metal powders leads to a substantial increase in thermal conductivity, with aluminum and copper powders exhibiting the most pronounced improvements in polypropylene and polyethylene, respectively. This enhancement is beneficial for applications requiring effective heat dissipation. The mechanical properties, including tensile and flexural strength, were also significantly improved, particularly in polyethylene and polypropylene composites. The addition of 20% metal powders resulted in a marked increase in both tensile and flexural strength, making these composites suitable for high-performance applications where mechanical robustness is required. Epoxy resin composites also exhibited improvements, with stainless steel powder contributing to enhanced strength characteristics.

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