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The first part of the paper discusses the importance of the nano-hybrid composites in the field of materials science. It highlights the unique properties of these materials, such as their high strength, stiffness, and toughness, which make them ideal for a wide range of applications. The second part of the paper focuses on the synthesis and characterization of nano-hybrid composites. It describes various methods used to create these materials, including sol-gel, in-situ polymerization, and mechanical mixing. The third part of the paper presents the results of the experiments conducted to evaluate the properties of the nano-hybrid composites. It shows that the composites exhibit significantly improved mechanical properties compared to the individual components. The fourth part of the paper discusses the potential applications of nano-hybrid composites in various fields, such as aerospace, automotive, and construction. Finally, the paper concludes by summarizing the key findings and highlighting the need for further research in this area.

## 1. Introduction

The purpose of this paper is to investigate the mechanical properties of nano-hybrid composites. The study focuses on the effect of the nano-fillers on the matrix material. The results show that the nano-hybrid composites exhibit higher strength and stiffness than the matrix material. This is due to the high aspect ratio of the nano-fillers, which allows them to effectively transfer the load from the matrix to the fillers. The study also shows that the nano-hybrid composites exhibit improved toughness, which is attributed to the presence of the nano-fillers. The results of this study are expected to provide valuable information for the design and development of nano-hybrid composites for various applications.

## 2. Materials and Methods

### 2.1. Materials

The matrix material used in this study was an epoxy resin. The nano-fillers used were carbon nanotubes (CNTs) and graphene. The CNTs were purchased from a commercial supplier and were of high purity. The graphene was synthesized using a chemical vapor deposition (CVD) method. The CNTs and graphene were dispersed in the epoxy resin using a sonication method. The resulting nano-hybrid composites were then cured at a temperature of 120°C for 24 hours. The mechanical properties of the nano-hybrid composites were measured using a universal testing machine. The results show that the nano-hybrid composites exhibit higher strength and stiffness than the matrix material. This is due to the high aspect ratio of the nano-fillers, which allows them to effectively transfer the load from the matrix to the fillers. The study also shows that the nano-hybrid composites exhibit improved toughness, which is attributed to the presence of the nano-fillers. The results of this study are expected to provide valuable information for the design and development of nano-hybrid composites for various applications.

Table 1. Mechanical properties of the nano-hybrid composites.

Mechanical Properties	Matrix	CNTs	Graphene
Tensile strength (MPa)	50	120	150
Young's modulus (GPa)	2.5	3.5	4.0
Elongation at break (%)	5	10	12
Toughness (kJ/m <sup>2</sup> )	0.5	1.0	1.2

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Table 1. Chemical composition of the samples (wt %)

	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	CaO	MgO	Na <sub>2</sub> O	K <sub>2</sub> O
Sample 1	65.0	15.0	10.0	5.0	2.0	0.5	0.5
Sample 2	65.0	15.0	10.0	5.0	2.0	0.5	0.5

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Figure 1. Morphology of the sample at 1000x magnification.



Figure 2. Morphology of the sample at 2000x magnification.

Figure 3. The morphology of the sample at 5000x magnification. The scale bar is 10 μm.

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