Behaviour of hybrid blend Composite Materials Reinforced by Aluminium Nanoparticles and Glass Fibres

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Abstract. This research aims to study the effect of glass fibres and aluminium nanoparticles on the mechanical properties of composite materials containing epoxy resins and phenol formaldehyde in different proportions. The results showed that adding phenol formaldehyde to epoxy in a ratio of (10/90) improved the properties, and that reinforcement with glass fibres and aluminium nanoparticles increased the use of these materials by increasing their applications through the possibility of replacing the basin liner with paint. Composite materials used in the research. Compounds are common and used in almost every field, and the idea for reinforcement is to improve the properties of the compounds.

Keywords: Hybrid blend, Mechanical Behavior, Aluminum Nanoparticles, Glass Fibers.

1. Introduction

The effect of reinforcements with aluminium nanoparticles and glass fibres of composite materials has been studied, as studying the properties of composite materials under the influence of forces and loads under different conditions is of great importance to determine the suitability of these properties for the applications of these materials, as epoxy mixtures with formaldehyde resins in different mixing ratios were used to study the mechanical properties. And to analyse these properties and the potential replacement of some mechanical parts and compare them with the results of other parts. Polymers were and still are an essential and widespread part of our lives. They have been used in the production of automobile parts, airplane tires, phones, computers, human body prostheses, and many other physical goods [1]. Composite materials are characterized by light weight, chemical resistance, and corrosion resistance, as well as homogeneous composition, and infinite possibilities to derive any behaviour of a distinct material. This unique design flexibility and other characteristics, such as ease of manufacture, high specific strength, toughness, shape-forming, wear resistance, durability, adaptability and cost-effectiveness, has attracted the attention of engineers, and has become the 21st century material to meet the requirements of aerospace, marine and medical technologies. [2]. The use of polymeric materials in the manufacture of auto parts is constantly increasing and it is expected that this trend will continue, especially the materials that make up the structure of the current appearance.
of cars to reduce the weight, as well as the decrease in fuel consumption, which is the main reason for choosing polymeric materials, and therefore the future growth of their use will lead to new applications in cars. It concerns comfort, safety, and part integration [3,4]. Technological development depends on advances in the field of materials, and therefore one must be an expert to realize that the design of cars or aircraft will be more advanced to withstand service loads and harsh conditions [5]. A composite material is produced by combining two or more materials, often materials with different properties. The two materials work together to give a compound with distinct properties, and we can easily distinguish different materials from each other because they do not dissolve or mix with each other [6,7]. Composites are used not only for their mechanical properties, but also for use in electrical, thermal, tribological and environmental applications [8]. Composite materials represent a big step in the continuous endeavour to improve materials, as the idea of composite materials is neither new nor modern, and therefore nature is full of examples using the idea of composite materials [9]. In the twentieth century, modern composites were used when these materials were reinforced with fiberglass and resins, by building boat and aircraft hulls from these composite materials, and the widespread use of composite materials increased due to the development of new fibres such as carbon, boron, Kevlar and new composite materials systems fortified with metals and ceramics [10]. A composite material is a lightweight structural compound obtained by combining continuous fibres in one or more directions, and at other times strengthening them with fibres and particles, as they provide strength and rigidity, while the polymer acts as a bonding agent. Figure 1.a shows the reinforced with the un-continuous fibres that are not continuous, while Figure 1.b shows the reinforced with the discontinuous fibres that are randomly directed [8].

![Figure 1](image_url)

**Figure 1.** Short fibre composite materials [8].

2. Experimental Work

Material: The phenol formaldehyde resin andLEYCO-POX 103 epoxy resin. Sample preparation: The phenol formaldehyde and epoxy resin were mixed in different proportions, the epoxy resin (EP) is a solvent-free component, with low viscosity, and the second component is the activator of the first component, and the mixing ratio of the first component and the second component is A: B = 2: 1. The reinforcement has been made with aluminium nanoparticles and glass fibres, the basis of the textile fiberglass is SiO2 silica, and the shape and its mechanical properties are shown in the Figure and Table 1 [6].
2.1. Epoxy risen and Resole resin preparation
Composite materials were prepared in the form of plates, which were poured into moulds of glass panels with dimensions (200 × 200 × 4) mm, after which the epoxy and hardened resins were determined by the appropriate mixing ratio for the hybrid resins as in Table 2. After that, the best ratio was chosen, and then reinforced with glass fibres and aluminium nanoparticles.

Table 2. The mixing ratio of the components of epoxy resin and phenol

| No. | mixing ratio of Epoxy risen | mixing ratio of Resole resin |
|-----|-----------------------------|-----------------------------|
| 1   | 100%                        | 0%                          |
| 2   | 95%                         | 5%                          |
| 3   | 90%                         | 10%                         |
| 4   | 85%                         | 15%                         |
| 5   | 80%                         | 20%                         |
| 6   | 70%                         | 30%                         |
| 7   | 60%                         | 40%                         |
| 8   | 50%                         | 50%                         |

The test samples consisted of a mixture of epoxy and phenol formaldehyde reinforced with glass fibres and supported with aluminium nanoparticles. The mould is made of glass plates with dimensions (20x15x4) mm, and placed on nylon panels to prevent the sample from sticking. As for the composite material consisting of epoxy and phenol formaldehyde resin, the 90% epoxy resin was mixed with 10% resin manually and automatically by a mixing machine that rotates at 800 rpm for 20 minutes to obtain a good homogeneity between the hybrid and hardened resin and remove the air bubbles trapped in the sample. The composite material was obtained from the materials used by weighing the glass fibres in the mixed resin mixture, then spreading it into the mould symmetrically on the hybrid resin, then using a toothed steel cylinder to obtain the uniformity in the thickness of the mixture layer, then pouring it into the mould at room temperature, then leaving The mixture for 24 hours, then the test samples are machining by digital control machines. And after conducting tests on those samples, these materials were used in lining the paint basins of Diyala Company–Metrology Laboratory. Figure 3.
Figure 3. Paint basins for chemicals

Figure 4. Hardness Test Instrument
Figure 5. Impact Test Instrument.

This test mainly consists of a pendulum impact test as shown in Figure 5, the Sharpy test, in which a standard test piece is used that can be broken with a swinging hammer flux. The failure mechanisms that occur in materials due to rapid stress differ in their behavior, as the ductile material under static stress becomes a brittle material under rapid dynamic stress, and thus the impact strength (I.S) is calculated by applying the relationship:

\[ I.S = \frac{U_c}{A} \] \hspace{2cm} (1)

Where:-
Uc: is the fractional energy (joules) determined by the Charpy Effect Test Tool.
A: It is the cross-sectional area of the sample.

3. Results and Discussions

3.1. Tensile Strength test

The mechanical properties were measured at room temperature (20-30) degrees Celsius, where mechanical test instruments were used to measure the tensile properties and it is the most widespread mechanical properties of any material, the tensile strength is the maximum load that the sample can withstand before it breaks under a gradually increasing load. Slowly during the tensile test, as the resin is a brittle material and its tensile strength is very low, but upon cementing the properties will be significantly improved, and these properties are increased by increasing the added weight ratios because they occupy more space inside the resin allowing for better load distribution. Table 3 shows the final tensile values, which show the changes in tensile strength depending on the mixing ratio.

| Specimen No | Ultimate Tensile Strength (UTS) (Map) |
|-------------|-------------------------------------|
| EP          | 61                                  |
| EP/GF       | 178                                 |
| EP/GF/Al    | 236                                 |
3.2. Hardness test
The hardness is the resistance of the material to penetration by the hardest material, and the hardness values D showed that the results of the mixing ratio are different. Table 4 shows the hardness of mixtures of compounds. As for the hardness properties, resins are non-hard and low materials. This is what we see in Table 4, but when you add rezole to it, the stiffness property will improve clearly, and it will improve when reinforced with glass fibers and aluminum nanoparticles, and it will increase clearly, and the values of the stiffness property will be doubled when reinforcing with fibers and nanoparticles, because the increase in hardness is through The added weight ratios increase because it occupies more space within the resin, allowing for better load distribution [11].

Table 4. Shore D Hardness of the composites blends.

| Sample No | Hardness No. |
|-----------|--------------|
| EP        | 79.4         |
| EP/GF     | 93           |
| EP/GF/Al  | 96.7         |

3.3. Impact strength test
Table 5 shows the values of shock resistance and the weight ratios of the mixture. Impact resistance is generally low for resins due to their thickness. After mixing, the shock resistance value increases. This is due to the fact that the mixing materials will bear the bulk of the impact energy exerted on the overlap material which improves this resistance. Thus, the impact resistance increases when affixing to glass fibers, and increases after affixing to aluminum nanoparticles with the presence of glass fibers [11].

Table 5. The Effect of mixing ratio on the Impact Strength.

| Sample No | Hardness No. |
|-----------|--------------|
| EP        | 12.5         |
| EP/GF     | 53.3         |
| EP/GF/Al  | 86.1         |

4. Conclusions
1. The presence of phenol formaldehyde gives an increase in properties with an increase in the epoxy ratio.
2. Fiberglass reinforcement increases its tensile and stiffness properties, so that it gives greater strength to withstand external pressures.
3. An improvement in tensile, hardness and strength properties were observed when cementing with aluminum particles compared to non-reinforced composite materials.
4. The use of composite materials consisting of epoxy resins and phenol formaldehyde at a ratio of (90/10) % that leads to better bonding with mechanical properties.
5. It is preferable to line the paint basins with a layer of composite materials reinforced with glass fibers and aluminum nanoparticles used in the study.

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