International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 04 Issue: 01 | Jan -2017 www.irjet.net p-ISSN: 2395-0072

Comparison of mechanical properties of the Zro2 and TiO2 filler epoxy composite

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Abstract - *Effect of TiO2 and ZrO2 filler on mechanical properties of the epoxy polymer has been investigated experimentally. TiO2 and ZrO2 filler epoxy composites are fabricated by hand layup technique in a mold and cured under light pressure at room temperature for 48 hour indivisibly. Specimen preparation and testing was carried out as per ASTM standards. The results indicated that the due to the filler addition the mechanical properties of the epoxy composites is enhances the best resistance observed in the ZrO2 filler composites. The strength variation is observed in the trend of plain>petrel>diesel>mineral>saline in Both tensile and flexural.*

Key Words: ZrO2, tensile, TiO2, Epoxy.

1.INTRODUCTION

Environmental awareness today motivating the researcher's world-wide on the studies of natural fiber reinforced polymer composite. This is because natural fibers have the potential of serving as alternative for artificial fiber composite [1-4].

Increase of environmental awareness has led to a growing interest in researching ways of an effective utilization of rice by-product, from which rice husk is particularly valuable due to its high content of amorphous silica and amorphous carbon as the main constituents. [5, 6].Compares to the conventional sources of silica rice husk ash as a ceramic raw material possess advantages like fine particles size and higher reactivity due to its amorphous nature.

There are many applications of natural fibre composites in everyday life. However the main disadvantage of natural fibre is their hydrophilic nature. They also have a poor environmental and dimensional stability that prevent wider use of natural fibre composites. The possibility of using these materials in outdoor applications makes it necessary to analyze their mechanical behaviour under the influence of different weathering conditions such as humidity, saline water, sunlight or micro-organisms. The moisture absorption by composites containing natural fibres has several adverse effects on their properties and thus affects their long-term performance

Sreekumar et al. [7], while studying water absorption characteristics of sisal fiber polyester composites found that diffusion coefficient decreases with chemical treatment of fiber. In addition to this the chemical treatment also decreases water absorption capacity of the composite. They also showed that the composite with benzoyl-chloride treated sisal fiber composite exhibited lower water absorption capacity.

Agrawal et al. [8] performed a saline chemical treatment on oil palm fibers. Silane (siH4) used as coupling agent which modified the interaction between the fiber and the matrix and also increases the tensile strength. Joseph et al. [9] performed a Benzoylation treatment on sisal fibers. They treated the sisal fibers with NAOH and benzoyl chloride (C6H5COCl) solution and observed that treated fibers have reduced hydrophilic nature and increases interaction with the matrix.

For potential application of filler polymer composites a comprehensive study on the moisture absorption characteristic and its effect on mechanical properties are required. In this chapter, the characteristics of moisture weight gain and effect of moisture absorption on mechanical properties of both TiO2 and ZrO2 epoxy composite under different environments (mineral water, Saline water, Petrol and Sub-zero temperature) are investigated.

1.1 Sub Heading 1

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2. MATERIALS AND METHODS

2.1 Raw materials used

For preparation of composite the following materials have been used;

1. Epoxy
2. Hardener
3. TiO2 powder
4. ZrO2 powder.

2.2 TiO2 powder

Titanium dioxide (TiO_2) is a white strong inorganic substance that is thermally stable, non-combustible, ineffectively solvent, furthermore, not delegated perilous concurring to the United Nations' (UN) Globally Fit System of Classification furthermore, Labeling of Chemicals (GHS). TiO_2, the oxide of the metal titanium, happens actually in a few sorts of rock furthermore, mineral sands. Titanium is the ninth most normal component in the world's outside. TiO_2 is commonly considered as being synthetically dormant.

Fig-1: TiO_2 powder

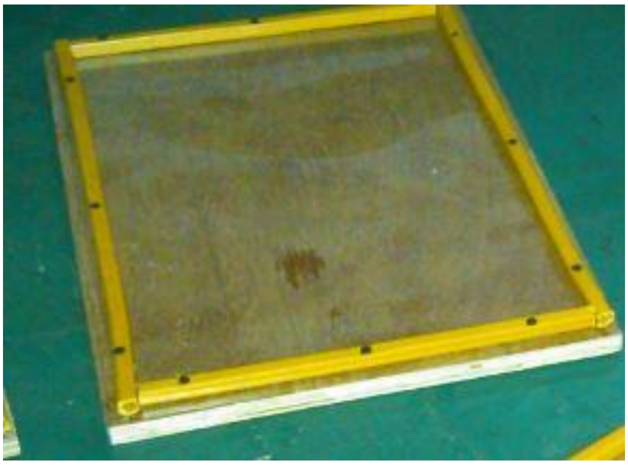
2.1.3 ZrO_2 powder

Zirconia, for the most part comprising of ZrO_2, has the most elevated mechanical quality and break durability at room temperature of all significant fine ceramic production. It is utilized to make cutting sharp edges, scissors and blades. It is additionally utilized for pump parts because of its unrivaled surface smoothness.

Fig. 2 ZrO_2 powder

2.2 Composite Fabrication

The hand lay-up technique was used for preparation of the samples. A wooden mold of dimension (190x270x6) mm was used for casting the composite sheet. A mold release spray was applied at the inner surface of the mold for quick and easy release of the composite sheet. For different weight fraction of fibers, a calculated amount of epoxy resin and hardener (ratio of 10:1 by weight) was thoroughly mixed in a glass jar and placed in a vacuum chamber to remove air bubbles that got introduced. Then calculated amount of TiO_2 and ZrO_2 is added separately with a weight percentage of 2, 4, 6, 8, 10wt% to the mixture of epoxy resin and hardener. Then the composite mixture is poured in to the mold. Care has been taken to avoid formation of air bubbles. Pressure was then applied from the top and the mold was allowed to cure at room temperature for 72 hrs. During application of pressure some amount of epoxy and hardener squeezes out. Adequate care has been taken to consider this loss during manufacturing so that a constant thickness of sample can be maintained. This procedure was adopted for preparation of 15 weight percentage of fiber reinforced epoxy composite slabs. After 72 hrs the samples were taken out from the mold and then cut in to required sizes as per ASTM standards for different test.



(a)

(b)

Fig- 3 (a) Wooden mold **(b)** Composite samples

2.3 Study of Environmental Effect

The performances of ZrO_2 composite and TiO_2 epoxy composite under different environmental conditions are essential to study. Therefore effect of environment on performance of titanium dioxide and zirconium dioxide epoxy composite samples were subjected to following environments:

- Mineral water exposures.
- Saline water exposures
- Petrol exposures
- Diesel exposures

2.3.1 Moisture absorption and swelling thickness tests

These tests are used to investigate the effect of moisture absorption and swelling thickness on l fibre reinforced composites. The aim of this test is to compare the influence of both fibre reinforcement and water uptake on mechanical properties of fibre reinforcement composites and the related kinetics and characteristics of the water absorption and swelling thickness. There are different mechanisms to moisture diffusion in polymeric composites. The first mechanism having capillary transport into the gaps and flows at the interfaces between fibre and the matrix. The second mechanism having transport of micro cracks in the matrix arising from the swelling of fibres. And the third mechanism having diffusion of water molecules inside the micro gaps between polymer chains. In this test, firstly the samples were dried in an oven for 24 h at 103±2°C .The samples were immersed in boiling de ionized water for given time period (up to 30 min) after that removed from the boiling water and cooled in de-ionized water for 15min at room temperature. The samples are exposure at different time intervals until the water content in samples reached up to saturation and measured the weight and thickness of the samples. By using weight and thickness difference of the samples, the moisture absorption and swelling thickness was calculated. The percentage weight and thickness gain of the samples was measured at different time intervals and the moisture content and swelling thickness versus square root of time was plotted. Moisture absorption $Ma(\%)$ and thickness swelling $Ts(\%)$ was calculated by using following equations,

$$Ma(\%) = \frac{wa_t - wa_o}{wa_o} \times 100 \qquad (5)$$

$$Ts(\%) = \frac{Ts_t - Ts_o}{Ts_o} \times 100 \qquad (6)$$

Where wa_o, Ts_o, wa_t and Ts_t indicate the oven-dry weight and thickness swelling and weight and thickness swelling after 't' time.

2.3.2 Tensile and flexural testing

Specimens for tension and flexural tests were carefully cut from the laminate using diamond wheel saw and finished to the accurate size using emery paper. The standard test method as per ASTM D 3039-76 and ASTM D790 has been used; length of the test specimen is 140 mm. Specimens were loaded in three point bending with a recommended span to depth ratio of 16:1. The span of 70mm and a cross-head speed used for the flexural tests (three point bending) was 5mm/min. The tensile test and flexural are performed in universal testing machine INSTRON H10KS.The tension test is generally performed on flat specimens. The most commonly used specimen geometries are the dog-bone specimen and straight-sided specimen with end tabs. At the rate of loading, 0.5mm/min was used for testing. For each stacking sequence, five identical specimens were tested and the average result is obtained.

3. RESULTS AND DISCUSSION

Figure 4.-8 shows the comparison of tensile strength of the ZrO_2 and TiO_2 filler composites after exposed to different environments(Mineral ,Saline water, petrol and diesel). The tensile strength of the ZrO_2 filler composites is more when compared to the TiO_2 filler composites. The degradation of strength is observed in the composite exposed to different environments. It is also clearly observed that the maximum strength is observed in the 6wt% filler in both the ZrO_2 and TiO_2 filler composites. The strength of the composites increase as the filler addition increases up to 6wt% and starts degrading beyond 6wt% this may be due to the excess filler addition and which leads to poor bonding in the fillers.

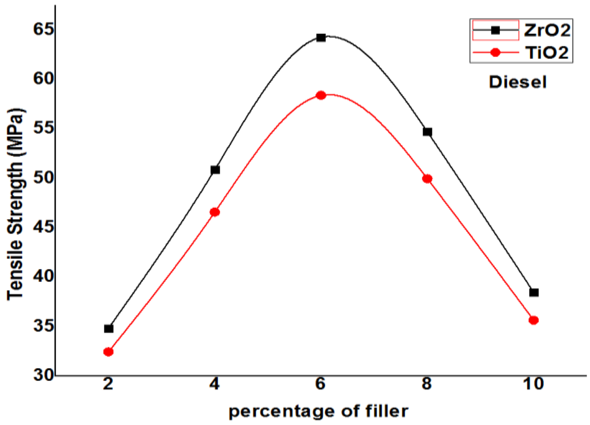


Fig-4 Tensile strength of ZrO_2 and TiO_2 composites after exposed to Diesel

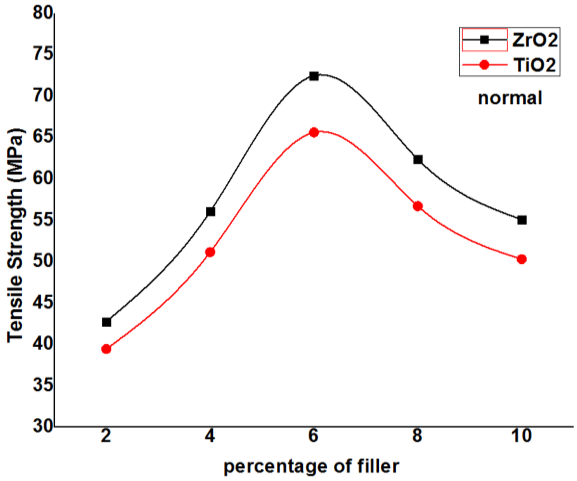


Fig-5 Tensile strength of ZrO_2 and TiO_2 composites

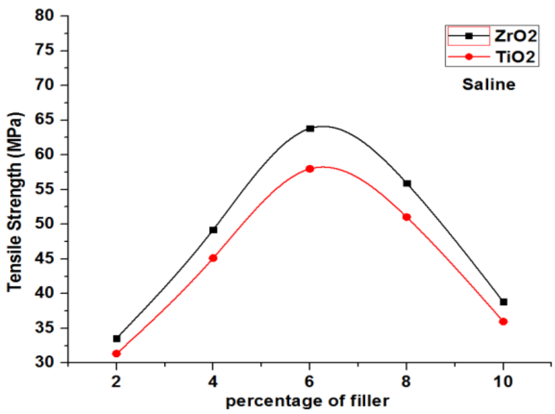


Fig-6 Tensile strength of ZrO_2 and TiO_2 composites after exposed to Saline water

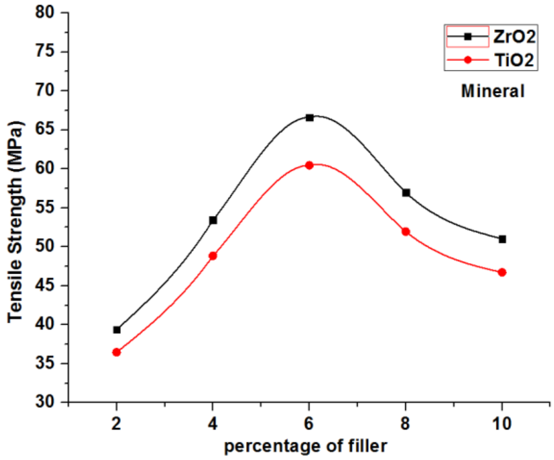


Fig-7 Tensile strength of ZrO_2 and TiO_2 composites after exposed to Mineral water

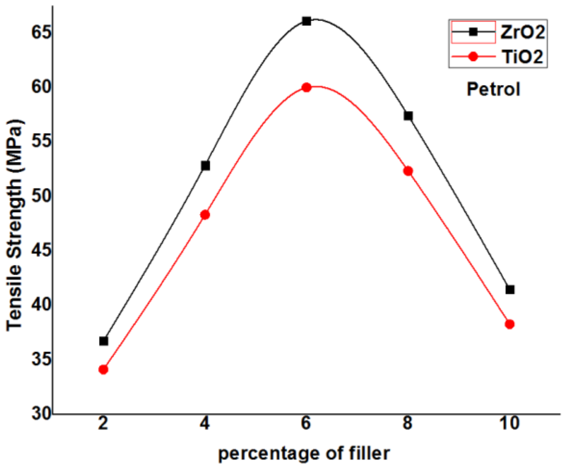


Fig- 8 Tensile strength of ZrO_2 and TiO_2 composites after exposed to petrol

Figure 9-13 shows the comparison of flexural strength of the ZrO_2 and TiO_2 filler composites after exposed to different environments (Mineral, Saline water, petrol and diesel). The flexural strength of the ZrO_2 filler composites is more when compared to the TiO_2 filler composites. As the filler addition increase the flexural strength of the composites increases up to 8wt% and starts degrading beyond the 8wt%. After exposing to different environments the strength degradation is observed as observed in tensile strength.

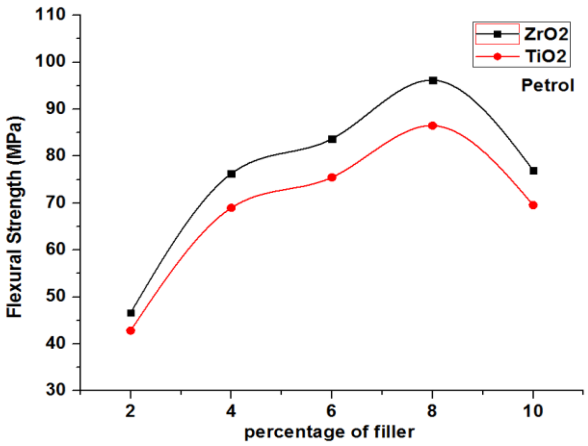


Fig-9 Flexural strength of ZrO_2 and TiO_2 composites after exposed to Petrol

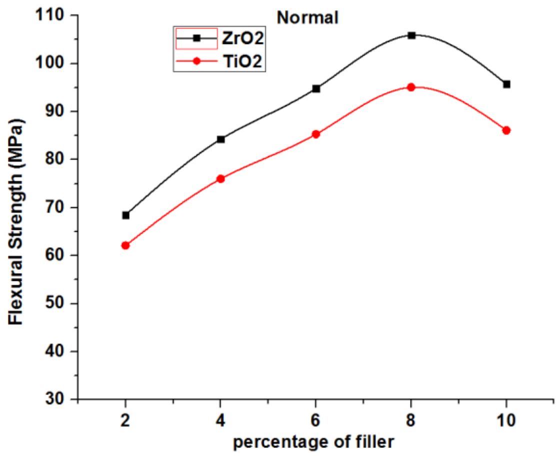


Fig-10 Flexural strength of ZrO_2 and TiO_2 composites

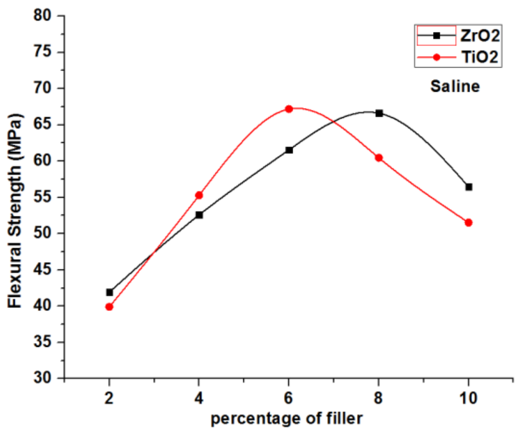


Fig-11 Flexural strength of ZrO_2 and TiO_2 composites after exposed to Saline water

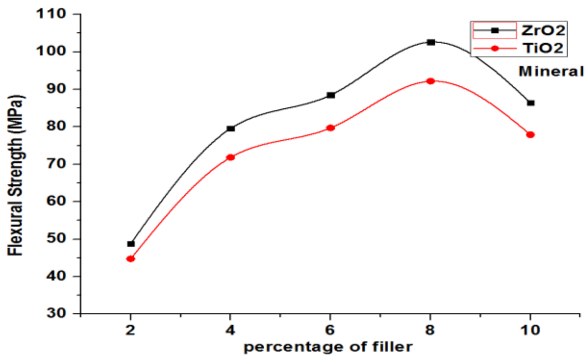


Fig. 12 Flexural strength of ZrO_2 and TiO_2 composites after exposed to Mineral water

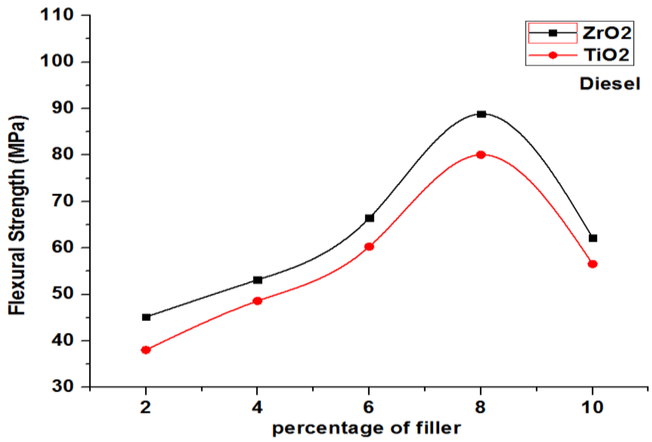


Fig. 13 Flexural strength of ZrO_2 and TiO_2 composites after exposed to Diesel

4 CONCLUSIONS

Based on experimental results, this study has led to the following conclusions:

- The TiO_2 and ZrO_2 can successfully be used as reinforcing agent to fabricate composite by suitably bonding with epoxy resin.
- On increasing the volume fraction of filler the strength, modulus increases and the best combination is found with 6% wt. fraction in tensile strength and 8wt% filler in flexural strength.
- By incorporation of TiO_2 and ZrO_2 fillers into polymer mechanical properties are improved to great extent.
- The strength variation is observed in the trend of plain>petrel>diesel>mineral>saline in Both tensile and flexural.

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