# Study on Mechanical Properties and Corrosion Behaviour of Bio-Polymer Metal Matrix Composite

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***Abstract :*** Bones and joints in human body made of a characteristic composite material are cracked because of exorbitant loads and effect pressure. The different kinds of bone breaks which happen in human body rely on split size introduction, morphology and its area. As a rule, the mean burden on the hip joint is required up to three to multiple times of the body weight amid hopping, running and so forth. .These heaps are fluctuating relying upon the exercises, for example, standing, sitting, running, climbing the staircase and so forth. The material of prosthesis and the sturdiness of exchange bone material is of basic significance, since it generally decides how load is exchanged through the stem. In the geometry and structure of the material, the young's modulus of a material is basic plan variable.

The polymeric bio composites reasons, why they are winding up most basic composites, incorporate their minimal effort, high quality and straight forward in assembling standards by molding process. In any case, they experience the ill effects of poor mechanical properties like higher wear rate, lower hardness and Young's modulus.

An endeavor has been made to create crossover bio polymer framework composites utilizing high thickness poly ethylene as the lattice material with Titanium Oxide ($TiO_2$) as the fortification material with differing percentage utilizing extruded infusion shaping machine. The distinctive testing in particular, ductile, hardness, flexural quality, thickness, fractography, erosion and wear test were directed on the standard examples arranged. It is discovered an apparent upgrades in the mechanical properties of the half and half polymer framework composite, which can be utilized for assortment of uses in the human body bone substitution. For this situation, their application in orthopedic as implantable material in the bone medical procedure has been considered and examined. These composite materials have discovered wide use in orthopedic applications, especially in bone obsession plates, hip joint substitution, bone concrete and bone unite**.**

***Keywords:*** *A Polymer Matrix Composite, polyethylene+ Titanium Oxide ($TiO_2$) particles, Orthopaedic applications.*

## I. INTRODUCTION

Bone, which is a characteristic composite material, comprises principally of collagen filaments and an inorganic bone mineral framework as little precious stone called apatite. Collagen is the fundamental sinewy protein, the composite of mineral part in the body. Cartiligen is a collagen based tissue which contains expansive protein saccharide atoms that structure a gel in which collagen sinewy are reinforced [1] . Articular cartillery frames the uncovering surfaces of the moveable joints of the body which carries on direct visco flexible. It has additionally low coefficient of grinding (μ) to a great extent credited to the nearness of senovial liquid that can be pressed upon compressive stacking [5].

Bone trade materials are required for assortment of reasons[11] . They may require when segment of bone is missing and the hole should be filled. There are a few choices for the sorts of bone substitution.
1)Allograft: implies material from another patient.
2)Autograft: It implies utilizing material of an individual from various site.

Manufactured materials are steadily winding up progressively prevalent. Hydroxy apatite is arranged effectively, however it is fired, which is too weak to ever be utilized without anyone else for extensive scale applications. Composites of a hydroxy apatite with degradable polymers can likewise be utilized which enables unresolved issue and fill the equivalent. Bio materials both common and manufactured materials are utilized to supplant some portion of a living framework. This gathering of materials incorporate metals, (for example, treated steel, titanium amalgam) and earthenware production, (for example, alumina and toughened Zirconia) known for high quality, pliability and protection from wear, yet metals display low bio similarity, erosion and high stiffness contrasted with tissues and furthermore metal particles which cause hypersensitive responses. Pottery are known for their great bio compatibility, consumption opposition however principle disadvantage is weakness, low crack quality, hard to create and low mechanical properties and high thickness. In any case, polymer composite bio-materials give better elective decision to supplanting in light of bio-similarity, erosion safe and simple to create and so on. Composite materials are having the benefits of high explicit modulus and solidarity to weight proportion more over; they have better sturdiness than anticipate break engendering.

Metal lattice and Fiber strengthened composite materials have been utilized nowadays because of their solidness, less weight and better similarity. The fundamental prerequisites for human joints incorporate mechanical property (yield pressure, versatility, Young's Modulus, Fatigue quality), Physical properties (thickness, attractive properties and so on.), synthetic properties (opposition to various types of erosion and wear corruption), natural property (bio – similarity) and lesser expense [1]. The accompanying polymer composite bio-materials are utilized for different bio restorative applications.

Utilization of various composites in various part of body

1. Total knee substitution: polyethylene, carbon filaments and ultra-atomic weight polyethylene.
2. Total hip substitution: carbon strands Epoxy carbon fiber-Polysulphone, polyethylene carbon filaments and so forth.
3. Finger joint: ultra-high atomic weight polyethylene, polysulphone and so forth.,
4. Bone concrete: Titanium, carbon filaments ultra high sub-atomic weight polyethylene, Kevlar strands/polytetra fluoroethylene (PTFE) and so on.,
5. Dental embed: Carbon strands/carbon, Silicon carbide (SiC)/Carbon.
6. Bone plates and screws: Polyethylene/hydroxy apatite, carbon fiber/epoxy, Kevlar fiber/poly carbonate and so on.
7. Cartilage substitution: Carbon strands/PTFE, Polyurethane.

At present steel, titanium and titanium based compounds are by and large generally utilized for the bone substitution of materials and furthermore unique fired materials like hydroxyl apatite, Alumina, Zirconia are broadly looked into materials for embed applications and they are industrially created notwithstanding of their mind-boggling expense. Diverse bio-perfect polyethylene (PE) and poly ehterther ketone (PEEK) based materials are being utilized as low stacking bearing application for bone and other bio restorative applications for having great bio-similarity.

From the writing overview, it is discovered that, the majority of the examination was completed regarding bio-perfect materials utilizing tempered steel 316L, Ti-6AL-4V composite, Co-Cr combination, hydroxyl apatite (HAP), ultra high sub-atomic weight polyethylene (UHMWPE),), Titanium oxide (TiO2), Silicon carbide (Sic) and so forth as the substitution material for different sorts of bone cracks like knee joint, hip joint, lower leg joint and furthermore for dental applications[18].

## II. METHODOLOGY

This paper features about the investigation of fundamental properties required to trade bone materials for different kinds of bones and joints broken by the combination of bio-perfect, half and half polymer network composites.

Polymer framework composite is the material comprising of polymer (sap) as network joined with a sinewy strengthening scattered stage. Polymers make perfect lattice material, they can be handled for example created all the more effectively, with light weight and offer attractive mechanical properties. The explanations behind the choice of these composites are minimal effort, high quality and basic assembling standards.

The a portion of the ordinarily utilized zones of these biomaterials are joint substitutions, all out hip substitutions, bone plate and bone bond, dental inserts for tooth obsession, heart valves, contact focal points, vascular unions, dialysis film, catherters, pace producers, drives, vein prosthesis and opthalmagic gadgets. In spite of the fact that a natural material bone can regularly be considered similarly as artificial building materials because of the idea of its union, it is probably going to demonstrate a greater number of varieties in estimated properties than with ordinary designing materials, which are because of the accompanying components.

1) Age
2) Gender
3) Location in the body
4) Mineral substance
5) Amount of water present
6) Diseases

With the expansion in the time of people, the bone turns out to be less thick and the quality of these bones likewise diminishes, subsequently increasingly vulnerable to crack. The different mechanical properties of bio materials examined are 1) Tensile quality 2) Hardness 3) corrosion 4) wear

In view of geometry, structure and material of prosthesis the young's modulus of material turns into a basic plan variable as it to a great extent decides how load is changed through the stem. So as to consider the toughness of exchange material which is of basic significance, an endeavor has been made to build up a half and half bio polymer network composites utilizing HDPE as the lattice, with titanium oxide as the support material with changing rate. Utilizing guideline of blend of composites, to be specific, with 5%, 10%, and 15% weight titanium oxide and the strengthening HDPE as lattice material, half and half biopolymer composites were manufactured utilizing infusion forming machine.

Utilizing extruder infusion type shaping, every one of the examples arranged according to ASTM Standard D3039. They were exposed to different tests, mechanical and properties to explore and think about the different properties like tensile quality, wear, hardness tests, corrosion

Salt splashed consumption test were additionally directed to examine wear conduct of bio polymer composites. This is being done to evaluate the appropriateness of bio polymer composites (for example HDPE + Titanium oxide) in bio medicinal applications.

The schematic work plan of this examination work is appeared as follows.

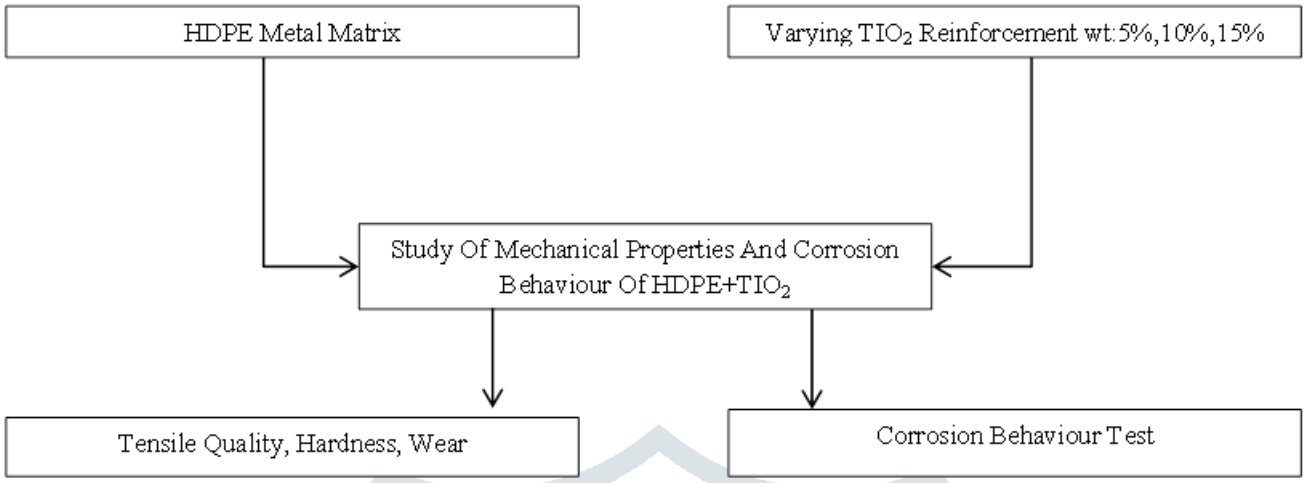


Figure 1. Organization Chart

List of samples prepared with different composition are shown in Table 1.

Table.1

| SAMPLE | HDPE | $TiO_2$ |
|---|---|---|
| 1 | 95 wt % | 5wt % |
| 2 | 90 wt % | 10 wt % |
| 3 | 85 wt % | 15 wt % |

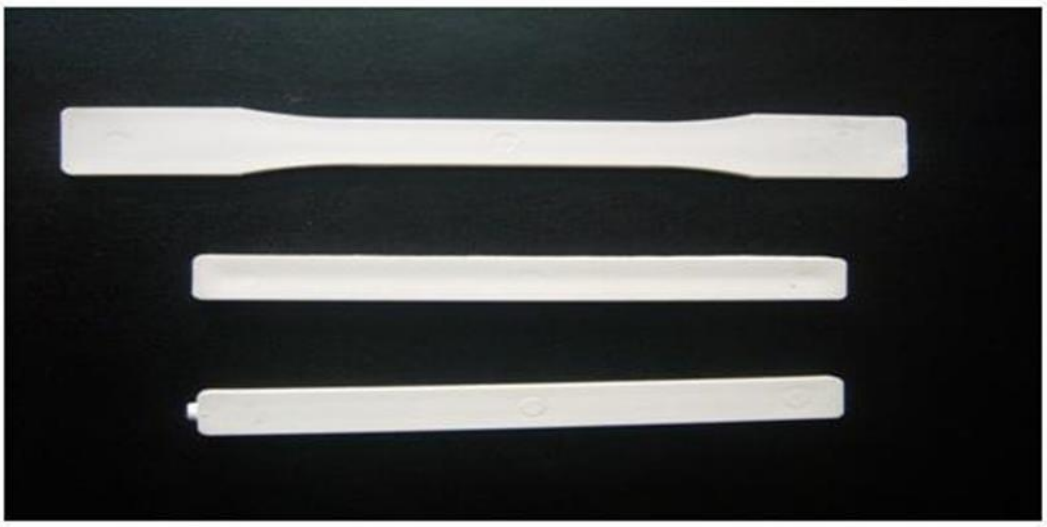

Figure 2. Photos of examples of HDPE +$TiO_2$

## III. RESULTS AND DISCUSSIONS

1. Tensile Test: It is induced from the test outcomes that, the rigidity of composite material increments with expanding level of filler substance to be specific, 5%, 10%, 15% Titanium Oxide consistent. Maximum tensile strength of 23.6MPa

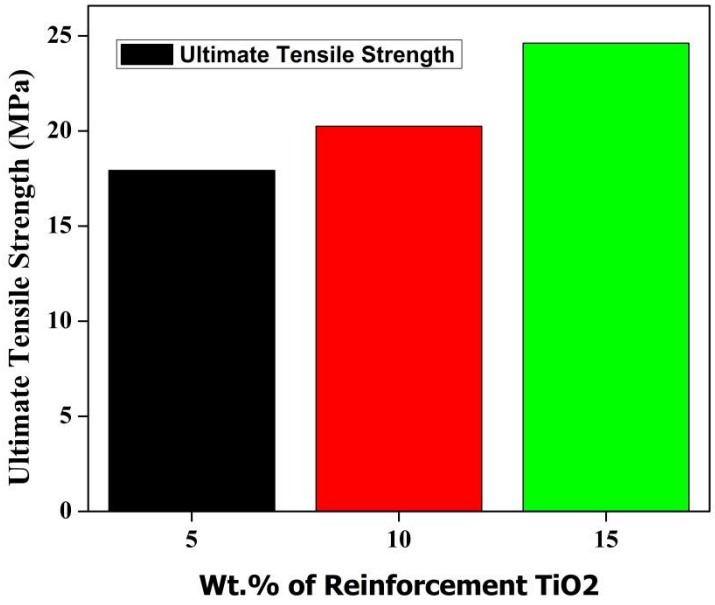


Figure 3. Variation of Tensile Strength for varying percentage of Reinforcement

From the tensile test result it is inferred that increasing the percentage of $TIO_2$ in HDPE matrix increasing the ultimate tensile strength of bio polymer

2. Hardness: Demonstrates the variety in the hardness of example with changing level of support. The most extreme hardness shore D hardness number is observed to be 55.33


Figure 4. Hardness test

From the hardness test result it is inferred that increasing the percentage of $TIO_2$ in HDPE matrix increasing the hardness of bio polymer

3. Corrosion test/Salts prayed showered test: It has been watched for a given time span of 48 hours, no Corrosion was found on all

Table 2. Corrosion Test for 5% of $TiO_3$ & 10% of $TiO_3$ & 15% of $TiO_3$

| | |
|---|---|
| Test solution | Sodium Chloride(AR Grade) in distilled water |
| Method of cleaning after test | Running water |
| Volume of solution collected/Hr/80$Cm^3$ | 1.40ml/hr. |
| Concentration of test solution | 5%&10%&15% of Nacl |
| Test Temperature | 35.6 |
| Ph of Test solution | 6.96 C |
| Exposure Period | 48 hours |

Observation:

| SL no | Time in Hours | Observation |
|---|---|---|
| 01 | 24 | No corrosion was Observed |
| 02 | 48 | No corrosion was Observed |

4. Wear investigation Pin on plate wear test: The wear information for example wear misfortune in grams for various loads to be specific, 10 N, 20N and 30N at steady speed of 286 rpm for various examples are appeared. The accompanying perceptions were made in the wear examination test.

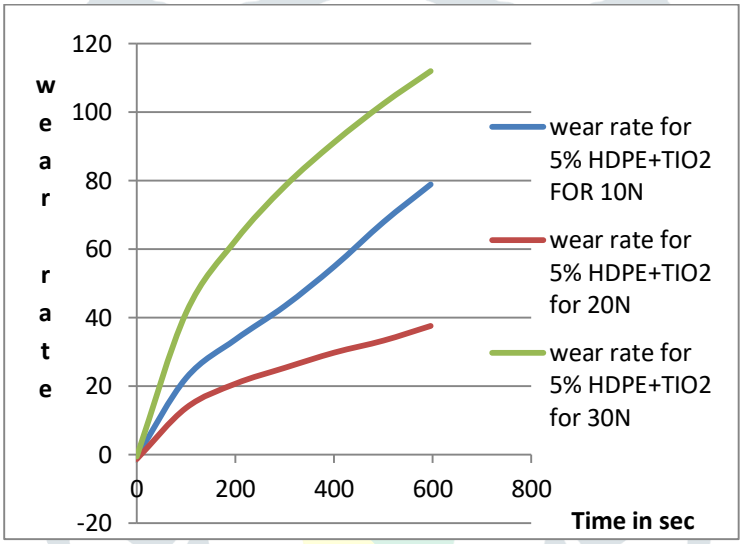


Figure 5. Plot of HDPE + 5% $TiO_2$ (Time vs Wear rate)

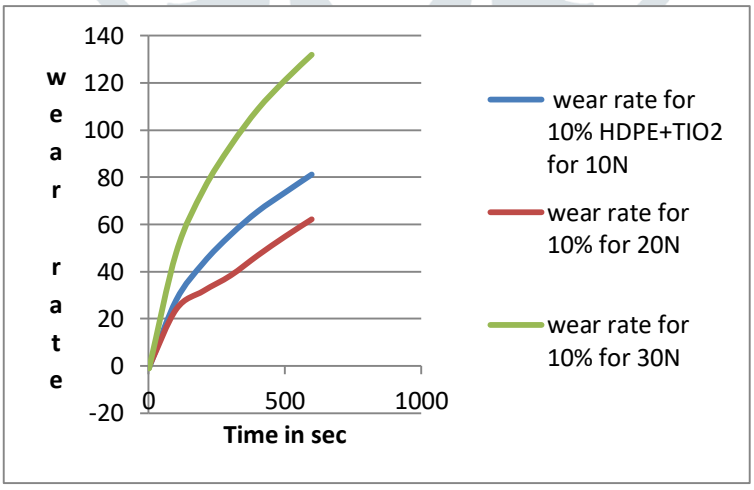


Figure 6. Plot of HDPE + 10% $TiO_2$ (Time vs Wear rate)

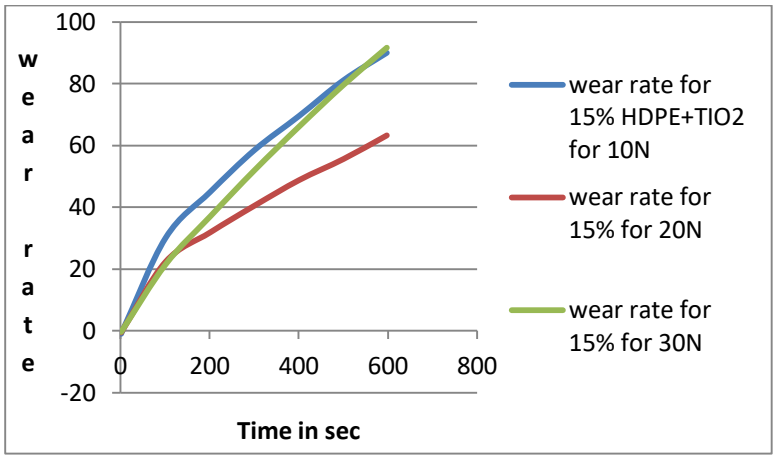


Figure 7. Plot of HDPE + 15% $TiO_2$ (Time vs Wear rate)

From the graphs, we conclude that

- With increase in the load on the specimen, the wear loss of composite increases. Whereas, wear loss decreases with increase in the percentage of reinforcement of composite.
- It is also noticed with increase in sliding time, wear of the component also increases.
- The coefficient of friction as well as frictional force of composite decreases with increase in percentage of reinforcement

## IV. CONCLUSION

Based on the investigations carried out on hybrid polymer matrix composites, the following conclusions were made

**1)** It is seen that, the tensile strength, hardness and bending strength and wear of this hybrid polymer composite increases with the increase in percentage of reinforcement.

**2)** Maximum tensile strength of 18.8 MPa, Maximum hardness of 55.33 shore D number

**3)** No corrosion was seen on the examples after the consumption test was directed for a period span of 48 hours at PH estimation of 6.96.

**4)** Based on various tests, it is recommended that, (HDPE+15% TiO2) reinforcements could be used as a suitable for bone materials, in orthopaedic applications. Maximum tensile strength of 23.6 MPa, Maximum hardness of 55.33 shore D number

**5)** This polymer matrix composite (HDPE+15% TiO2) have variety of applications in the human body and they can be applied on hard and soft tissues of implantable materials.

**6)** Composite materials are broadly utilized in orthopaedic applications especially in bone obsession plates, hip joint substitution, bone bond and bone unite. The examinations of every conceivable factor which may influence the existence time, together with reaction of human body, body parts, tissues and muscles changing itself with expanding age, might be performed by exceptional systems with refined methodology

**7)** A model of bone examples made of the above composite materials should be dissected in a host body conditions for similarity of human body.

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