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# CHARACERIZATION ON WEAR ANALYSIS ON POLYMER MATERIALS IN BIO-IMPLANTS

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***ABSTRACT***

*Polymer materials are being developed for use as orthopaedic implant materials. Wear is an issue of increasing importance in orthopaedic implants. particulate debris generated by the wearing of biomaterials may be a causal factor leading to osteolysis and implant loosening. Therefore, numerical and experimental studies were completed to characterize the wear of Polymer materials in comparison to current orthopaedic implant materials. Wear Analysis of a composite material hip stem implanted in a femur. The Polymer implant exhibited 10-40% lower contact stresses in the distal region compared to a SS316L implant of identical design.. An identical series of experiments was run for comparison to a current orthopaedic implant material Two domains of motion were studied; a composite ring-on-HA disc large amplitude sliding wear test; and a composite pin-on-HA disc small amplitude fretting regimen. Nominal contact pressures during testing were Proper Loading and Speed for sliding and fretting tests, respectively. Fretting and sliding abrasive wear tests resulted in the composite material exhibiting a lower wear rate than the titanium-alloy. The magnitude of the difference was greatly dependent on the contact pressures, sliding amplitudes, and counter face material properties.*

***Keywords:*** *Polymers, PEEK, Wear, Implant*

## 1. INTRODUCTION

Over the years Metal has established itself as the best available bio implant material. With the advancement in the field of material science, metallurgy and designing, the development for more advanced bio materials having better properties than SS-316L is observed. It has been observed that one of the most important properties governing the suitability of the material to be a bio implant is 'wear resistance 'Corrosion Resistance' and also the fatigue resistance. But in the recent trend Steel as been completely replaced by other materials like alumina, composites, and also polymers which can have a very good biocompatibility then Steel

### Bio-Implants

An object made from non living material that is deliberately inserted by a surgeon into the human body where it is intended to remain for a significant period of time in order to perform a specific function. Despite great number of metals and alloys known to man, remarkably few warrant Preliminary consideration for use as implant materials. The relatively corrosive environment combined with the poor tolerance of the body to even minute concentrations of most metallic corrosion products eliminates from discussion most metallic materials. Of the possible metallic candidates, tantalum and the noble metals do not have suitable mechanical properties for the construction of most orthopedic tools and implants, while zirconium is in general too expensive Today, titanium, cobalt chrome, zirconium SS316L and titanium alloys are the most frequently used biomaterials for internal fixation devices because of a favorable combination of mechanical properties corrosion resistance and cost effectiveness when compared to other metallic implant materials

**Polymers Comparison to Metals**

**Table 1: Polymer Materials to Metals**

| POLYMER COMPARISON TO METALS | | |
|---|---|---|
| **STEEL** | **BRONZE** | **ALUMINIUM** |
| Polymer has cheaper manufacturing cost | Peek has better mechanical properties | Peek has cheaper manufacturing cost |
| Polymer has fewer leachables | Peek is harder | Peek is harder |
| Polymer has better Dry Wear properties | Peek has Better Wear & Friction | Peek has Better Wear & Friction |
| Polymer has 83% lower density | Peek has 85% Lower Density | Peek has 50 Lower Density |
| Polymer has less "memory" chemical absorption & release | Peek has low out gassing | Peek has very low out gassing |
| Polymer has better Chemical Resistance | Peek has better Chemical Resistance | Peek has better Chemical Resistance |

## Wear

The removal of material from solid surfaces by mechanical action.Most predominant in joint prostheses. Joint wears out but prior to this, the particles produced by wear (metal or polyethylene or cement particles) are phagocytosed by osteoclasts causing osteolysis and therefore loosening of components. The wear is very important process to show the material compatability or biocompatability which the materials suits and interacts with blood tissue for the implantation for the purpose of implants wear analysis and test necessary then corrosion test and fatigue test but these test should be conducted with suitable material where the implants should to be done for the material these causes the interaction for the material and the implant body.

**General Properties of PEEK, PEEK+30%G & PEEK+30%C**

**Table 2: Properties of Polymer Materials**

| **Property** | Approximate Value | | |
|---|---|---|---|
| | PEEK-Unfilled | 30% Glass Fiber | 30% Carbon Fiber |
| Tensile strength (@23oC) | 100 MPa | 150 MPa | 215 MPa |
| Tensile Modulus (@ 1% strain @ 23oC) | 3.5 GPa | 11.4 GPa | 22.3 GPa |
| Elongation at Break (@23oC) | 34% | 2% | 1.8% |
| Flexural Strength (@23oC) | 163 MPa | 212 MPa | 298 MPa |
| Notched Impact Strength (@23oC) | 7.5 kJ/m2 | 10.3 kJ/m2 | 5.4 kJ/m2 |
| Specific Heat (Melt) | 2.16 kJ/kgoC | 1.7 kJ/kgoC | 1.8 kJ/kgoC |

| | | | |
|---|---|---|---|
| Glass Transition Temperature | 143oC | 143oC | 143oC |
| Heat Deflection Temperature | 152oC | 315oC | 315oC |
| Coefficient of Thermal Expansion | < Tg 4.7 x 10-5/oC > Tg 10.8 x 10-5/oC | < Tg 2.2 x 10-5/oC | < Tg 1.5 x 10-5/oC |
| Long Term Service Temperature (Electrical) | 260oC | 240oC | N/A |
| Long Term Service Temperature (Mechanical - no impact) | 240oC | 240oC | 240oC |
| Long Term Service Temperature (Mechanical - impact) | 180oC | 220oC | 200oC |
| Specific Gravity | 1.30 | 1.51 | 1.40 |
| Water Absorption | 0.50% (50% rh) | 0.11% (50% rh) | 0.06% (50% rh) |
| Transparency | Opaque (grey/brown) | Opaque (brown) | Opaque (black) |

**Properties of Selected Materials**

The materials used were SS304, Polyetheretherketone(PEEK), Polyetheretherketone 30 % glass fiber (PEEK- 30%GF).The properties of the selected materials namely density, tensile strength and modulus of elasticity.

Table 3: Properties of selected materials

| Materials / Properties | Density (g/cm3) | Tensile Strength ultimate (MPa) | Modulus of elasticity (Gpa) Tension |
|---|---|---|---|
| SS36L | 7.85 | 510-620 | 190 |
| PEEK | 1.32 | 90-100 | 3.6 |
| PEEK 30% GF | 1.52 | 190 | 12 |

**Results of Wear**

Table 4 and Table 5 are the tabulated results obtained from the pin disc apparatus. The wear rate and the weight loss of all the materials were plotted on a graph where they were compared. The figure 1 and the figure 2 show the wear rate and the weight loss of the materials respectively.

Table 4 Tabulated results with pin disc apparatus

| MATERIALS | WEAR(microns) | Frictional force (N) | Coefficient of friction |
|---|---|---|---|
| PEEK | 220 | 12 | 0.300 |
| PEEK 30%GF | 450 | 30.4 | 0.760 |
| SS316L | 2005 | 18.6 | 0.465 |

**Table 5 Tabulated results with pin disc apparatus**

| **MATERIALS** | **INITIAL WT(gm)** | **FINAL WT(gm)** | **WEIGHT LOSS (gm)** |
|---|---|---|---|
| PEEK | 3.28463 | 3.28087 | 0.00366 |
| PEEK 30%GF | 6.70263 | 6.70050 | 0.00213 |
| SS316L | 7.12291 | 6.69361 | 0.42936 |

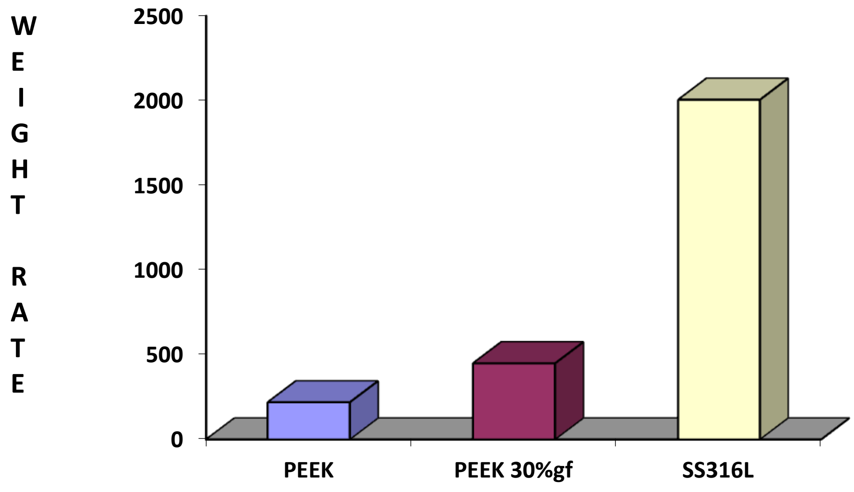


**Figure 1 Tabulated results with pin disc apparatus**

The above results shows the peek 30% which can be the best wear rate which is obtained in the wear factor for the different methods of using the technology for the different material testing and handling for the initial and final weight which can be used in the wear loss for the different wear factor can be used for the different materials.

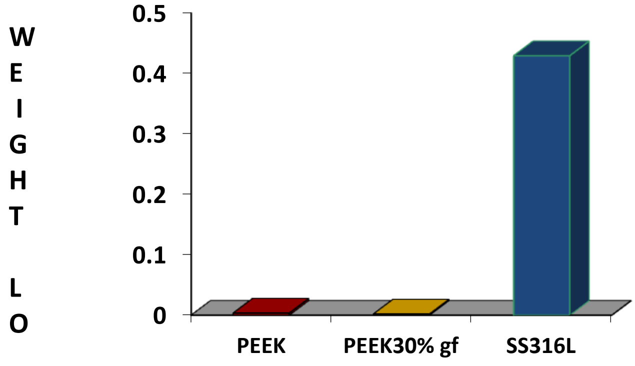


**Figure 2 Tabulated results with pin disc apparatus**

The above results shows the peek 30% which can be the best weight loss which is obtained in the of the material which is characterized for the material to be choose for the bio implants which is used among all the materials as by the material

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