

Investigation on Corrosion Behaviour of PEEK Biomaterial

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Abstract—The evolution of biomaterials is not a modern area of science, having survived for around half a century. The study of bio materials is called biomaterial science. A bio materials essentially a material that is used and adapted for a medical application. In medical applications, biomaterials are rarely used as isolated materials but are more commonly integrated into devices or implants. Biomaterials should possess good properties for implants so that there should be good bonding which prevails when co-operating with the body and the blood. Hence the implants are tested for various respective properties. SS-304 has established itself as one of the best available bio implant material. With the advancement in the area of science, metallurgy and engineering, the improvement for more advanced biomaterials having better properties than SS-304 have been emerged. This Paper constitutes corrosion study of PEEK and PEEK used as Biomaterial. Corrosion control of metals is an important activity of technical, economic, environmental, and aesthetical importance. The use of biomaterial is one of the best options of protecting metals and alloys against corrosion. The toxicity of organic and inorganic corrosion inhibitors to the environment has prompted the search for safer corrosion in biomaterial, most of which are biodegradable and do not contain heavy metals or other toxic compounds. Study of corrosion abilities shows the PEEK biomaterial which as the maximum withstanding of corrosive material than any other material for implant on material.

Key words: PEEK Biomaterial, Corrosion

I. INTRODUCTION

A biomaterial is designed to associate with natural system of a human body for a medicinal purpose - either a restorative (repair or supplant a tissue of the body) or an indicative one. As a science, biomaterials are around fifty years of age. The research on biomaterials is called biomaterials science or biomaterials building. It has encountered enduring and solid development over its history, with numerous organizations putting a lot of cash into the improvement of new items

Materials for biomedical purposes in the 21st century are huge business, with researchers introducing bio materials that are stronger, lighter and more durable like advanced plastics for implants like PEEK. Presently there are many different materials are used for the Implants and also continuous researches are going on to select the suitable material which exactly matches with the human body. The material chosen should show high performance and versatility to enable patients to lead a normal life as possible. In this Corrosion plays a main role in implants.

Biocompatibility is a general term used to describe the suitability of a material in the corrosive studies and also for exposure to the metals. It is the ability of a material to perform with an appropriate response in a specific application and is very dependent on the particular application or

circumstances. A material will be considered biocompatible in a specific application if it allows the body to function without any complications such as allergic reactions or other adverse side effects. Biocompatibility is not the same as sterility. Sterility is the treatment of a material to remove or destroy all living organisms including bacterial or fungal spores, and does not concern itself with the actual biocompatibility of the material

II. BIOCOMPATIBILITY

The biocompatibility assessments of PEEK biomaterial can be characterized into two classes particulate and implant form via different methods.

A. Implant Form

A rule, the cellular reaction for an artificial implant is encapsulation. A fibrous layer will be conformed to the implant material and from whatever is left of the body. This marvel can be maintained a strategic distance from by an alternate techniques like permeable covering or surface on the embed surface.

In a corrosion study the examination a PEEK-Optima based with was for a period of a time. In light of the perception of cytological reaction, just mellow incessant irritation containing a few macrophages was found in tissues nearby the PEEK gadgets. It showed that PEEK based inserts were especially persevered by the spinal tissues.

B. Particulate Form

There are few researches that provide details regarding the biocompatibility of PEEK wear particles.

For example, round molded PEEK particles (Dia of 40µm) were used in a creature demonstrate biocompatibility contemplate. The gained histopathology demonstrates recommends that PEEK based particles are innocuous to the spinal rope and nerve roots. It merits determining that the PEEK particles they utilized were entirely unexpected fit as a fiddle than the wear particles created from cervical TDR.

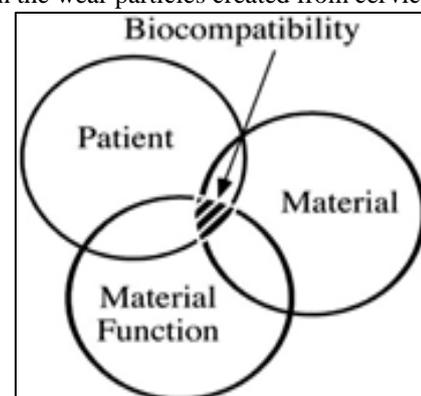


Fig. 1:

III. CORROSION BEHAVIOUR

PEEK have been increasingly employed as biomaterials for trauma, orthopedic, and spinal implants. We have synthesized the extensive polymer corrosion study as it relates to structure, mechanical properties, and chemical resistance of PEEK biomaterials. With this foundation, one can more readily appreciate why this family of polymers will be inherently strong, inert, and biocompatible when corrosion behaviour is variable lot of changes can occur in the implants. Due to its relative inertness, PEEK biomaterials are an attractive platform upon which to develop novel bioactive materials, and some steps have already been taken in that direction, sintered PEEK. However, to date, blended PEEK composites have involved a trade-off in mechanical properties in exchange for their increased bioactivity. PEEK has had the greatest clinical impact in the field of spine implant design, and PEEK is now broadly accepted as a radiolucent alternative to metallic biomaterials in the spine community. For mature fields, such as total joint replacements and fracture fixation implants, radiolucency is an attractive but not necessarily critical material feature.

IV. CORROSION FOR PEEK

Corrosion analysis is a bio chemical test which refers to the processes performed on the materials or the final products in order to come across the resistance of the materials to rust or corrosion under the various ecological conditions, including temperature, humidity and salt water. Hence such process is engaged to resolve, prohibit, prevent or mitigate problems associated to corrosion.

The comprehensive study and the course of action of Corrosion testing are required crossways a choice of productions for a range of requests. These vary from tactical agencies saying participation keen on obverse end manufacturing design processes, to retorting to alterations in examination backgrounds, necessities for cost and efficacy savings or to meet the requirements and, select equipment and chemicals, for repair or amenity with the required procedures. Convenience of corrosion test:

- It helps to estimate the corrosion percentage on the materials.
- It is employed to find the corrosion or rust formation on any materials or compounds under the service load characteristics.
- The corrosion layer in turn protects the inner part of the material, which can be determined by corrosion test.
- Helps to determine the chemical or bio chemical characteristics of the materials.
- Establishes the need for the process of the coating or some other methods for the extension of the life of the component.
- Very helpful in the preliminary assessment of the product to be usable in the corrosive environment.
- Greatly useful in the Machinery tools application.
- Corrosion test could be carried out in the galvanic corrosion system.
- Corrosion testing facility is of high cost.
- Salt solution Chemical properties may fluctuate with respect to temperature or ecological state.

V. METHODOLOGY

The technique employed is ASTM B117 Salt Spray method.

- In this method, the salt fog chambered is used for the intention to find corrosion on SS 316L and PEEK material.
- Here the sample solution used will be of 6.72 -7.2 pH with concentration of 5% NaCl and the collected volume will be around 1.85 – 2.0 ml/hr/80cm²
- Test is to be carried out at the controlled temperature of 35±1°C.
- The salt fog chamber used to expose samples to surroundings of droplets of warm saline solution for a constant analysis time. The samples are contacted by chloride ions, oxygen and water. Add elevated temperature to these three components and you have a seriously corrosive environment for any metal surface.
- It will be allowed for the 10hrs observation.
- After the test, the test sample will be washed with running water and distilled water, thus cleaning activity has been carried out.
- Observation hours will be for depending on the application.

VI. RESULTS & DISCUSSIONS

Following table 5.1 represents the corrosion test results for PEEK material used different solutions Corrosion test parameters of Polyetheretherketone

Sl. No.	Contents	Details
1	Concentrations of salt solution	5% NaCl
2	Test temperature(°C)	35±1
3	Volume of test-solution collected (ml/hr/80cm ²)	1.85
4	pH of the collected solution	6.72
5	Test Duration	10 hrs

Table 5.1: Salt Spray Test details

Observations for the PEEK material sample during the test (5% NaCl) are being tabulated as shown below in table 5.2

	ObservatiOn time					
	0 hr.	2 hr.	4 hr.	6 hr.	8 hr.	10 hr.
Sample 1	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.
Sample 2	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.

Table 5.2: At 5% NACL

This indicates the sample 1 & sample 2 observation of the corrosion test which tells for the 5% there is no corrosive part in the PEEK material which tells it is non corrosive material

Following table 5.3 represents the corrosion test results for PEEK material used different solutions for 6% NACL

Sl. No	Contents	Details
1	Concentrations of salt solution	6% NaCl
2	Test temperature(°C)	35±1
3	Volume of test-solution collected (ml/hr/80cm ²)	1.85
4	pH of the collected solution	6.72
5	Test Duration	10 hrs

Table 5.3: Salt Spray Test Details

Observations for the PEEK material sample during the test (5% NaCl) are being tabulated as shown below in table 5.4

-	ObservatiOn time					
	0 hr.	2 hr.	4 hr.	6 hr.	8 hr.	10 hr.
Sample 1	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.
Sample 2	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.

Table 5.4: At 6% NACL

Following table 5.5 represents the corrosion test results for SS316L material used different solutions for 6% NACL

Sl. No	Contents	Details
1	Concentrations of salt solution	6% NaCl
2	Test temperature(°C)	35±1
3	Volume of test-solution collected (ml/hr/80cm ²)	1.85
4	pH of the collected solution	6.72
5	Test Duration	10 hrs

Table 5.5: Salt Spray Test on SS316L of 6%NACL

Observations for the SS316L material sample during the test (5% NaCl) are being tabulated as shown below in table 5.2

-	ObservatiOn time					
	0 hr.	2 hr.	4 hr.	6 hr.	8 hr.	10 hr.
Sample 1	0	0	0.5	1	2	5
Sample 2	0	0	0.6	1.2	2.2	5.4

Table 5.6: SS316L At 5% NACL

In the present research wOrk, comparative study has been made On PEEK and SS 316L for various tests. Corrosion test findings tabulated in the fOllOwing the table 5.7 shows how corrosive nature of SS316L and PEEK material which is highly non corrosive and it is the best material for implants.

-	ObservatiOn time					
	0 hr.	2 hr.	4 hr.	6 hr.	8 hr.	10 hr.
PEEK	0	0	0	0	0	0
SS316L	0	0	0.55	1.1	2.1	5.2

Table 5.7: comparison Results of PEEK & SS316l

Observation has been made on PEEK and SS 316L material after corrosion test. The following figure represents the corrosion difference between the samples

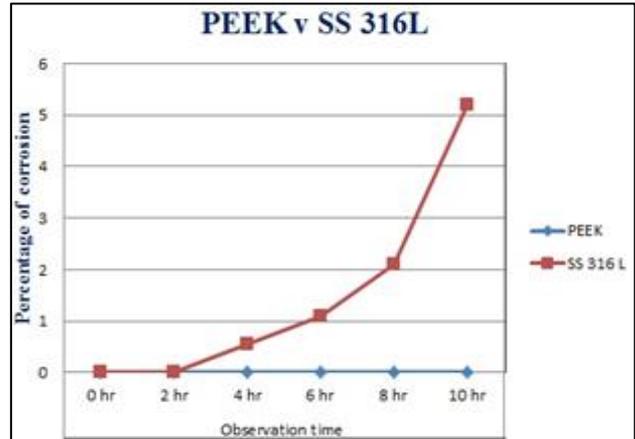


Fig. 5.1: PEEK & SS316L after Corrosion Test

This above figure 1 shows the after corrosion test how the change of phase takes place in steel ss316l material and the nature of PEEK material remains the same which suits best for biomedical applications

A. Comparison graph between PEEK & SS316L

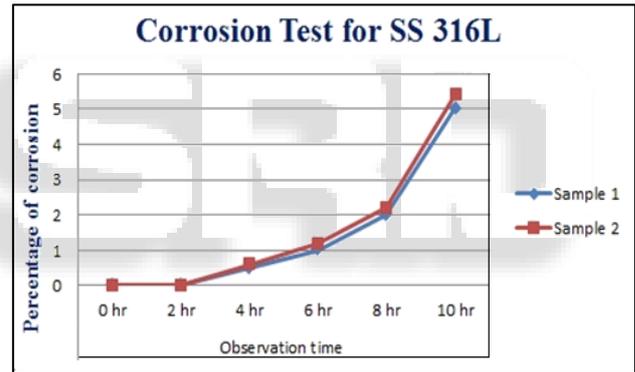
The graphical representation has been given below in Fig. 5.1 which shows the nature of curve for corrosion test on SS 316L.



Graph 5.1: Corrosion behaviour PEEK with SS316L

PEEK is the Corrosion free material which can be used as perfect biomaterial and also in medical devices as replacement to the SS 316L.

The graphical representation has been given below in Graph 5.2 Which shows the nature of curve for corrosion test on SS 316L.



Graph 5.1: Corrosion behaviour for SS316L

At the 10 hours salt-spray test, corrosion in the form of RUST has been found in SS316 L .Hence the SS 316L is toxic in nature and would be harm full to body.

VII. CONCLUSION

The process and investigation of corrosion which helps and shows that PEEK can be the material which equally acts and reacts for the feature biomaterials in the investigation study

- Corrosion test on the PEEK can gives us the inference that it will not undergo any type of corrosion formation during the salt solution test and also it can be concluded that it will be unaffected during the environmental body's reaction. Also the
- PEEK is Harmless and No injuries occurred to human body when it's being kept in contact with human body. Thus could be stated that Corrosion test results that the
- PEEK is the best replacement to SS 316L in the medical applications by considering all this investigations
- The study of PEEK tells us the material with the all the basic process can be revealed with the highest corrosive material can be rejected and quality of materials for the

implants through the process can be selected for the further investigation.

- Among all the materials polymers can be the best replacement materials because it's of good mechanical properties.
- PEEK has highly corrosion resistance material and as a longer life for implants.

VIII. SCOPE FOR FUTURE STUDY

There is a scope for future development for further investigation on this material.

- The study of the this work can be forwarded for investigation of Toxicity can be shown how much percentage of toxic content on PEEK material
- PEEK can be the best material if the further investigation can be done for the implants.
- PEEK as the wide range applications which can be used for the implants and can be used in all parts of the body with the further investigation in PEEK material
- The intersection of PEEK and SS316L shows in the form of corrosion PEEK is the best material. The process of ageing can be a happy one but for many the idea of growing old and the negative effects involved are a cause of stress,
- As general medicine improves across the globe the average lifespan of the human increases, and the bone life also can be increased by the smart materials like PEEK by further investigation

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