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Hydroxyapatite Plasma Spray Coating and Corrosion Test on Ss316l Existing Material used as Orthopaedic Implant Material

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ABSTRACT

This Research Paper constitutes the experimental investigation of corrosion test by using artificial Saliva and Hydroxiapatite plasma spray Coating on SS316L of the existing material used for orthopedic implant i.e. for Femur prosthesis. in this the specimen SS316L is dipped or immersed in artificial Saliva for one week at room temperature in accordance with ASTM G-31and analysis is carried out that there is no weight loss in the specimen and it indicates that there is no corrosion in the specimen and also the Hydroxyapatite plasma spray coating is done on this specimen from the experimental results the coating is withstand it is found that thickness of coating is around 50-70µm and hence we suggest this Bio-material to use for femur bone prosthesis.

Keywords – *SS316L ,Hydroxiapatite plasma spray Coating, artificial Saliva , Bio-Material, orthopaedic application-Femur Bone.*

INTRODUCTION

The Bone, which is a natural composite material, consists mainly of collagen fibers and an inorganic bone mineral matrix in the form of small crystal called apatite. Collagen is the main fibrous protein, the composite of mineral component in the body. Cartilage is a collagen based tissue which contains large protein saccharit molecules that form a gel in which collagen fibrous are bonded [1]. The Femur is the longest and strongest bone in the skeleton is almost perfectly cylindrical in the greater part of its extent [2] and A. J. Tonino et.al have confirmed the ability of HA to provide a sound stem-bone interface with a bone-implant bonding of greater than 43% at the proximally HA-coated shaft in four patients[3]. The best anchorage and the greatest amount of bony ingrowth was obtained by the mechanically stable implant coated with HA[4] metal-on-metal hip replacements have experienced a sharp decline in the last two years due to biocompatibility issues related to wear and corrosion products. Despite some excellent clinical results, the release of wear and corrosion debris and the adverse response of local tissues have been of great concern. There are many unknowns regarding how CoCrMo metal bearings interact with the human body. This perspective article is intended to outline some recent progresses in understanding wear and corrosion of metal-on-metal hip replacement both in vivo and in vitro[5] and also recent research is focused on the development of composite materials for implant applications which will mimic the nature. However, more studies are to be made to understand the behavior of composite materials in *in vivo* as their biofluid absorbing behavior, interfacial bonding between the matrix and reinforcement under loading are not clear at present in *in vivo* conditions[6]. Titanium oxide films are deemed to be chemically inert and biocompatible and hence suitable to be the barrier layers to impede the leaching of Ni from the NiTi substrate to biological tissues and fluids. In the work reported in this paper, we compare the anti-corrosion efficacy of oxide films produced by atmospheric-pressure oxidation and oxygen plasma ion implantation. Our results show that the oxidized samples do not possess improved corrosion resistance and may even fare worse than the untreated samples[7]. The fracture moments ranged from 20 Nm (for a pediatric specimen) to 630 Nm(for an adult male). The data showed a rapid increase in fracture moment during skeletal development with a plateau or peak during adulthood (approximately 25-45 years)[8]. and they found or developed binary Mg-Ca alloys for use as biodegradable materials within bone. The Mg-Ca alloys were mainly composed of two phases a(Mg) and Mg2Ca, and their mechanical properties and biocorrosion behaviors could be adjusted by controlling the Ca content and the processing treatment[9]. The mechanical properties and corrosion resistance in NiTi alloys have been improved by conducting.

C2H2, N, or O PIII. The leaching of Ni and Ti ions is significantly reduced[10]. new generation of alumina–zirconia nano-composites having a high resistance to crack propagation, and as a consequence may offer the option to improve lifetime and reliability of ceramic joint prostheses. The reliability of the above mentioned three bio-ceramics (alumina, zirconia and zirconia toughenedalumina) for THR components is analysed based on the study of their slow crack-growth behaviour[11]. Corrosion is one of the major issues resulting in the failure of biomedicalimplant devices. The nature of the passive oxide films formed, and the mechanical properties of the materials form some of the essential criteria for selection of alternative or development of new materials. In clinical terms, the biggest improvements could be made by better material selection, design, and quality control to reduce, or possibly eliminate corrosion in implant devices.Surface modification of 316L stainless steel is one alternative that is already in practice. That is, the coating of the alloy with hydroxyapatite plays a dual role: minimizing the release of metal ions by making it more corrosion resistant,as well as making the surface morebioactive and stimulating bone growth. Other surface modification techniques,such as hard coatings, laser nitriding,bioceramics, ion-implantation, and biomimetic coatings and materials all have great potential to improve the performance characteristics of biomedical implants and improving the lives of their recipients[12]. The coatings dealt with in this paper presented compact structures and good adhesion to the substrates. It follows that the films treated by ion beam mixing showed to be more resistant to the mechanical wear simulation tests. The equipment built in order to simulate the wear of the mobile parts of orthopedic implants was able to indicate differences among similar films, which allowed verifying adhesion problems as well as the erosion of the pins that were used in the tests[13]. As a result, it can be concluded that the material produced in this study (hydroxyapatite–polyethylene composite) is a cheap, easily producible and formable material which is proper for orthaepedics surgery. Moreover, due to very high hydroxyapatite content (80%) it is suitable for bone regeneration and does not cause any biocompatibility problem in vivo[14]. Types of corrosion that frequently found in implant applications are fretting, pitting and fatigue. Fretting corrosion most frequently happens in hip joint prostheses due to small movement in corrosive aqueous medium (Geringera, 2005)[15]. The micro/nanocomposite with inter/intragranular ZrO2 nanoparticles provides the possibility to design new materials with toughening mechanisms operating on a scale smaller than that of the matrix microstructure. This enhances the ‘‘intrinsic’’fracture properties of these materials and their wear resistance in the mild regime. Moreover, it makes them promising candidates for bearing applications and well-polished surface finish, for example for total joint replacements [16].

The aim of this research work was to determine how the structure of SS316L materials changes over time in terms of weight changes and artificial saliva obsorption. Purpose of this paper was to evaluate the influence of the corrosion and coating process on SS316L used for orthopaedic implants.

Table 1. Chemical reagents to artificial saliva [18]

Na_2HPO_4	0.260 g/l
NaCl	0.700 g/l
KSCN	0.330 g/l
KH_2PO_4	0.200 g/l
$NaHCO_3$	1.500 g/l
KCI	1.200 g/l

PREPARATION OF ARTIFICIAL SALIVA[17]

CONSTITUTENTS	AMOUNT PER 1000G OF PURIFIED WATER
Na2HPO 4	0.260g
NaCl	0.700g
KSCN	0.330g
KCl	1.200g
KH2PO 4	0.200g
NaHCO 3	1.500g

CORROSION TEST BY IMMERSION/DIPPING SS316L IN ARTIFICIAL SALIVA

The corrosion resistance was evaluated from potentiodynamic current-potential (I-E) curves. A standard three-electrode system was used. The working electrode was the specimen, the reference electrode with a constant potential was a saturated calomel electrode (SCE) and the counter electrode was made of vitreous carbon. The potential was imposed on the working electrode vs. the reference electrode and the current flowing between the specimen and the counter electrode was recorded continuously on a linear scale. The potential range used was between - 1.2 and + 1.6 V (SCE), and the scan rate was 20 mV s Two types of specimen holder have been used. The dipping technique was applied, so that only the surface was in contact with the solution only the surface was in contact with the electrolyte. This technique permits one to study many experimental conditions: for metals, the chemical composition, casting, heat treatment, internal stresses, machining, grinding, sandblasting, surface quality, roughness, superficial contamination, coating defects etc.; for solutions, the chemical composition, temperature, pH, aeration, stirring, organic or biological substance adsorption.[22]

A circular specimens of about 10mm diameter with a 30mm length is selected for the test according to the ASTM standards G31.

Table 1.Results of Corrosion Test

Material	Type of test	Solution used	Soaking Duration	Tempera ture	Remarks	Ph Value	Application
SS316L	Corrosion-Immersion test	Artificial Saliva	One week	Room tempera Ture 37c	No weight loss	7 - (Neutral)	Implant material for Femur bone

Implant matertials marked as SS316L after soaking in artificial saliva in 7days was marked as no weight loss it means that no corrosion takes place on the specimen .

COATING TEST BY PLASMA SPRAY METHODOLOGY:-

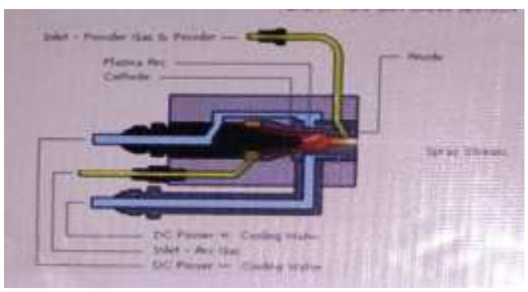


Fig: plasma spray machine

Coating is done by using Hydroxyappitite powder by using the plasma spray methodology. generally in the medical field plasma spray method is used on alloy material and also we get very good bonding strength on the material and the thickness on the coating specimen is arround about 50-70µm,For the purpose of coating the coating powder used was Hydroxy appitite of about 50 to 70 microns on the material.

PROPERTIES OF HYDROXYAPATITE POWDER:

- It is also called as an hydroxyapatite is naturally occurring mineral form of calcium apatite with formula Ca5(Po4) (OH)
- Pure hydroxyapatite powder is white naturally occurring apatite's also name brown, yellow or green.
- Hydroxyapatite can be found in bones and teeth's with in the human body thus it is used as a filler to replace amputated bone or as a coating to prome bone in growth in to prostheticimplants.

- It is costly powder compare to the other Bio-compatability powder like ceramic powder etc.

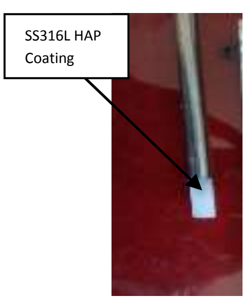
PLASMA SPRAY METHODOLOGY:

- A high temperature plasma stream is created by non-transferred plasma arc within the torch. Many gases may be ionized this way, organ or nitrogen with small additions of hydrogen and helium are popular choices.
- In an ionised gas, free electrons are been stripped from the atoms and recombination release a very significant thermal energy.
- The plasma stream can reach temperatures of 10,000 -50,000 degrees Fahrenheit

PROPERTIES OF COATING MACHINE:

SL.NO	Description	Details
1	Gun	3mb
2	Nozzle	GH
3	Argon Pressure	100 to 150 psi
4	Flow Rate	80 to 90 lpm
5	Hydrogen Pressure	50 psi
6	Flow Rate	15 to 18 lpm
7	Temperature	500 ^{o}c
8	Voltage	65 to 70 v
9	Powder Feed	50 to 65g/min
10	Spray Distance	2 to 4 inches

6.6 COATING TEST RESULTS



Coating is done by using Hydroxyappitite powder by plasma spray methodology. It is found that good bonding strength on the SS316L material and the thickness on the coating specimen is arround about 50-70µm

CONCLUSION

- From the Experimental test results of SS316L it is found that there is no weight loss or no corrosion on the specimen and finally suggest to use for the Femur bone prosthesis.
- From the Plasma Spray Hydroxiapatite Coating Experimental test results shows that very good bonding strength on the specimen.

FURTHER WORK

- Finite Element Analysis will be carried out.
- Testing like Fatigue test, shear test, Impact test, Moisture content test and thermal test
- We can compare the existing/ widely using material (SS316L) with Natural fiber (Sisal, Jute, Hemp fibre) or S-Glass fiber or E-Glass fiber or Hybrid Polymer composite material and these properties can be comparing to Orthopaedic Implants especially for Femur Prosthesis.

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