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Corrosion study of Ti-6Al-4V alloy in normal saline solution

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Abstract

Ti-6Al-4V is a grade 5 titanium alloy having vast application in both defence as well as in medical (bio-implant) field [1]. This alloy had been studied by many researchers in biofluid such as Hank solution. Literature available on corrosion behaviour of Ti-6Al-4V alloy in Normal Saline solution is scanty. It is essential to understand corrosion behaviour of Ti-6Al-4V alloy systematically in Normal Saline Solution. Also passivation behaviour had been shown by Ti-6Al-4V alloy in most of the environments. Thus it is of need to study Ti-6Al-4V alloy in Normal Saline solution which is a body fluid used most frequently in hospitals for medical treatment of the patients. Corrosion study is performed with the help of potentiostat by conducting potentiodynamic polarization and electrochemical impedance spectroscopy (EIS) techniques. The samples for electrochemical study were kept for immersion time of 24Hr. The surface was observed under optical microscope and results were correlated to obtain conclusion. The present study involves correlating corrosion behaviour of Ti-6Al-4V as a function of immersion time in Normal Saline Solution.

Keywords:- Ti-6Al-4V, Optical microscopy, Corrosion

INTRODUCTION

Every material is unique in its properties, thus having their application in different fields. Titanium and titanium alloys have a wide range of applications in aerospace, energetic, chemical and automobile industry. Some titanium alloys are excellent materials for biomedical use, especially as orthopedic alloys [1,2]. The most important characteristic features of these biomedical titanium alloys are high strength, low density, excellent corrosion resistance and the best biocompatibility among the metallic biomaterials. The Ti-6Al-4V alloy, originally having been developed as a

construction alloy for aircraft industry, belongs to the most significant alloys within the implant alloys for hard tissue replacement. As like as other material apart from above effective plus points, Titanium has an exceptional corrosion resistance, along with its typical property to form of passive layer.

EXPERIMENTAL

Material and Sample Preparation:-

Raw Ti6Al4V is machined to obtain samples for corrosion study [3]. Then the sample is polished with silica paper of grid 200, 400, 800, and 1200. Then final surface finishing is obtained by polishing the surface on lapping machine. The sample thus obtained is coated with non-conducting resin of ardelite and only one surface is kept open to the environment.

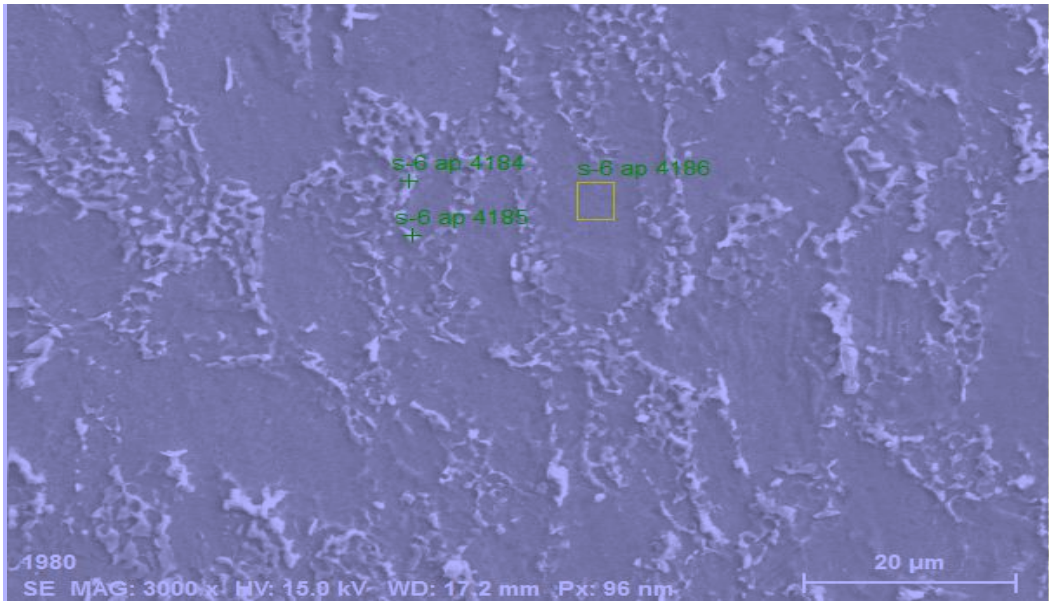

Fig (1): SEM Image of Microstructure at 3000x of Ti-6Al-4V surface.

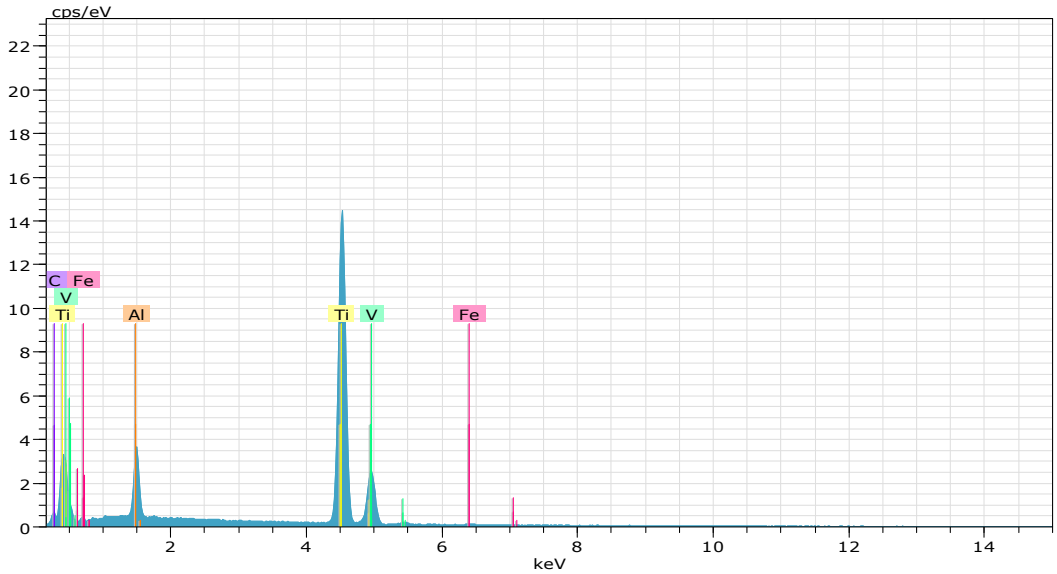

Fig (2): EDS Composition Vs KeV.

Table1:- Table showing chemical composition of Ti6Al4V.

Element	Al	V	C	Fe	Ti
Weight %	5.92	3.62	0.041	0.27	Balanced

Table2:- Table showing chemical composition of NS Saline

Element	Sodium Chloride	Water
Weight or Volume	0.9 g	100ml

The potentiostat used for corrosion study is a Gamry Instrument Reference 600. The OCP was carried out for 30 minutes so as to stabilise the potential. Then the EIS study was carried out for the frequency ranging between 100Hz to 0.01Hz, followed by a Tafel study for the voltage ranging between -350mV to +350 mV with respect to E_{OCP} scan rate of 1mV/sec. A calomel electrode is used as reference while Graphite as an Auxiliary electrode [4,5]. Electrical resistance can be defined as the ability of a circuit element to resist the flow of electrical current. But in real device systems, the circuit elements show much more complex behaviour which implies that we have to rely on 'Impedance', a more complex circuit parameter which basically represents the collective response of the device elements to an electronic current or voltage. The correlation of electrical parameter with the chemical and corrosion related phenomenon proved the EIS as the significant tool in evaluating corrosion resistance of any alloy [6].

RESULTS

Table(3):-Results of Corrosion Test.

SOLUTION	OCP (mV)	R_P (Ω)	E_{corr} (mV)	i_{corr} (A)	Corrosion Rate (mpy)
NS	**-254.7**	**0.1266×10^6**	**-328**	**3.020×10^{-9}**	**11.41×10^{-6}**

As shown in fig3 the OCP curve stabilized to -254 mV.(Table3)starting from -248 mV. This narrow range of between starting potential and stabilized value indicates the stability of the material in the NS environment.

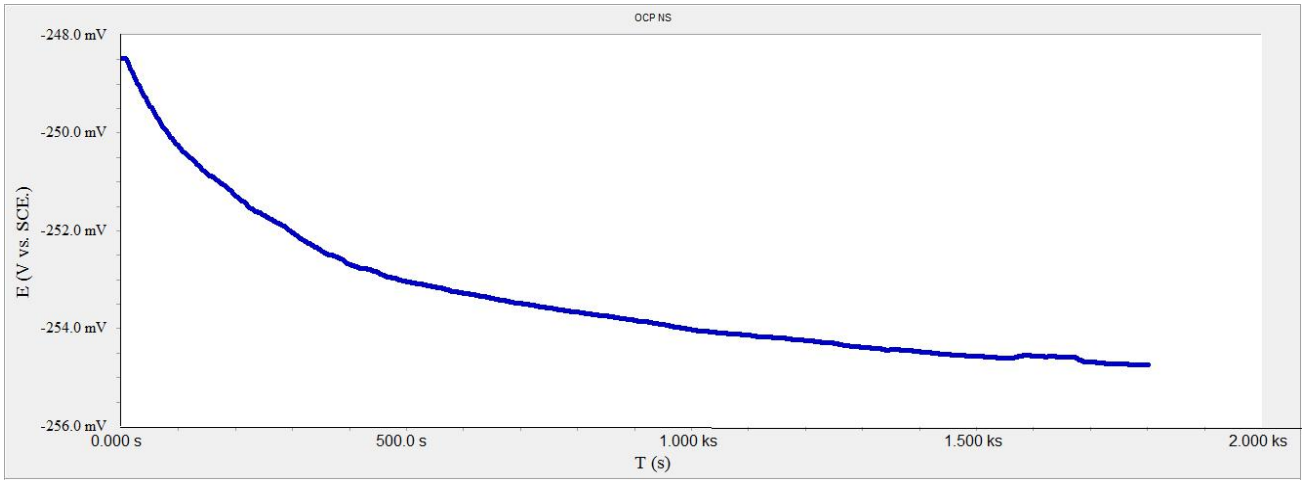

Fig (3): OCP curve for NS solution

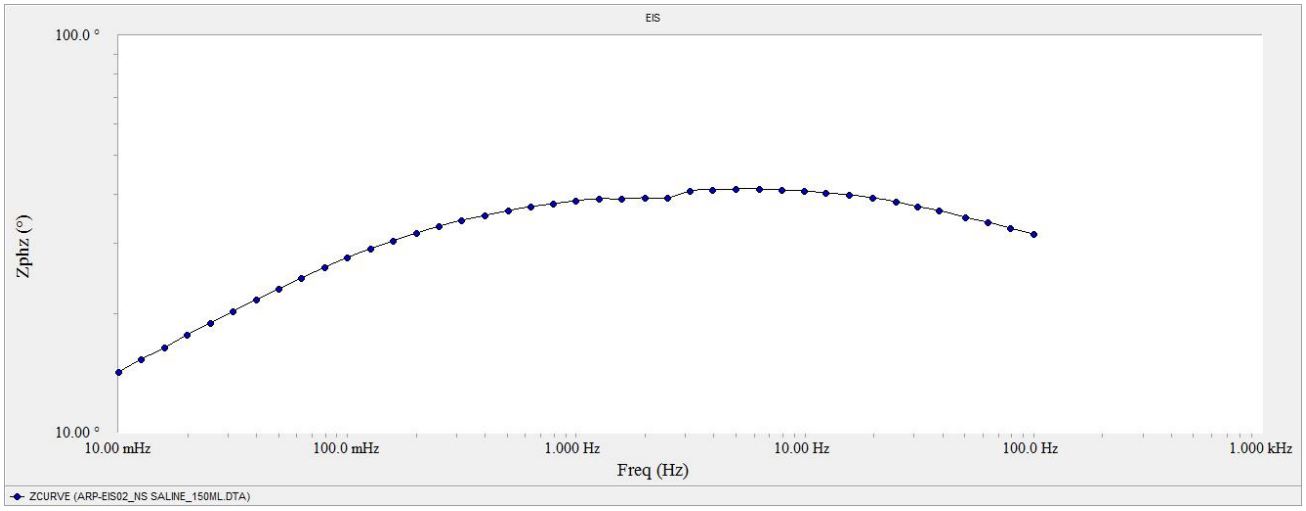

Fig (4): Phase angle plot showing phase angle vs. Frequency

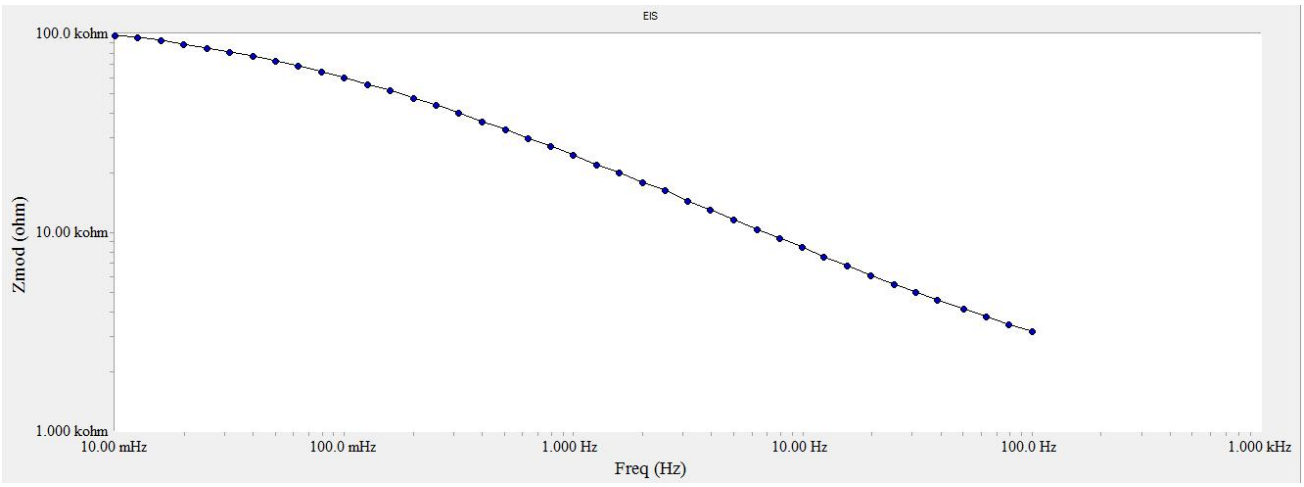

Fig (5): Pore Resistance vs. Frequency

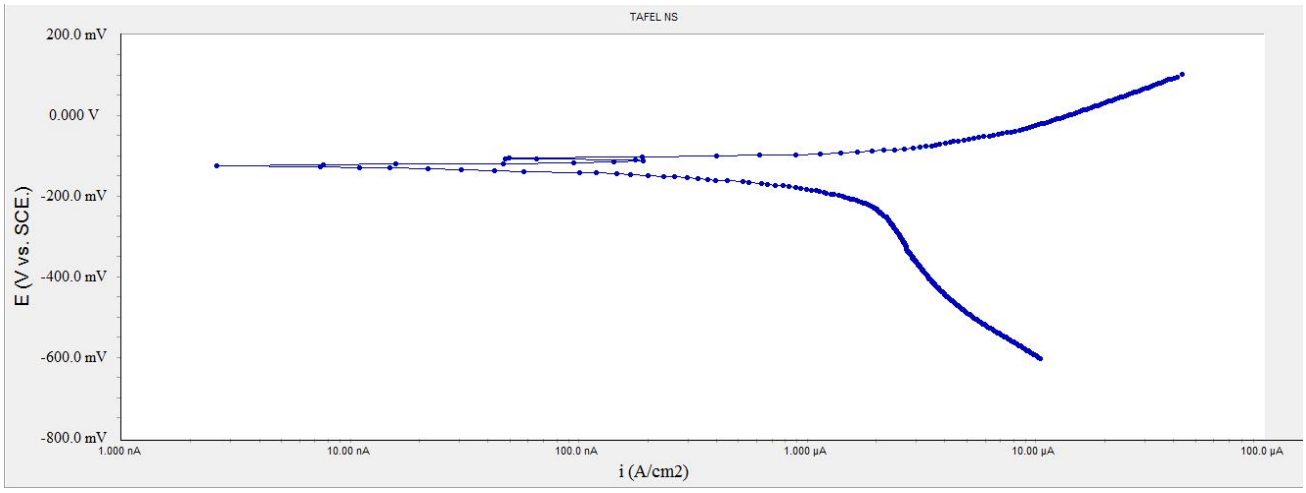

Fig (6): Tafel plot

For the higher values of frequency the specimen remain steady and had shown constant phase angle as shown in fig.4 which indicates its stability and intense corrosion resistance for aggressive disturbance and environment [7,8]. For lower frequency the sample has shown higher value of resistance i.e. 100K Ohm. But, it has decreased as the frequency is increased indicating its corrosion resistance decreased due to breaking of passive layer or due to the attack of environment on the metal surface[9]. The TAFEL plot has shown corrosion potential of -328Mv. Along with the corrosion current density of 3.020×10^{-9} pA. Very low value i.e. 11.41×10^{-6} mpy was obtained for the sample which shows that the Ti-6Al-4V alloy can be used in this environment [10].

CONCLUSIONS

(1) Corrosion rate of Ti-6Al-4V for NS environment is in the range of "micro mpy" i.e. 11.41×10^{-6} mpy indicating very high resistance to corrosion.

(2)OCP values shows that the passive layer has been formed on the surface because the OCP values have been stabilized with low difference with t=respect to the initil potential.

(3)The value of corrosion current density of 3.020×10^{-9} pA, showing less corrosive nature of material.

(4)R_P which is nothing but the material resistance to corrosion in the range of 100Kilo ohm showing very high resistance to corrosion

(5) Ti-6Al-4V can be preferably used as a material for Biomedical implants as per as the resistance to corrosion is concerned.

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