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Inhibitive Action of Ellagic Acid on Corrosion Behavior of (316 L SS) in Simulated Body Fluid

Zainab yaquob atiya
University of Baghdad
Al-Khwarizmi College of Engineering
Biochemical Engineering Department
zainaatia@yahoo.com

Murtdha Adhab .Siyah
Researcher Msa in Material Scientific
Ministry of Science and Technology- Iraq.
Email-walid7913@yahoo.com

Dr. abdulkareem
University of Baghdad
College of science
Department of chemical

Abstract

Potentiodynamic polarization measurements were used to study the effect of Ellagic acid on biocorrosion of (316 L SS) in Simulated body fluid (Ringer Solution) was used as the electrolyte .The temperature of the polarization test cell was maintained at 37±1^{O}C by thermo stated water bath to simulate the human body .The result from corrosion behavior investigated by electrochemical measurements appear the corrosion current density of (316 L SS) specimens in Ringer solution containing Ellagic acid was much lower than the values obtained in Ringer solution without Ellagic acid .

التأثير التثبيطي للاجك أسيد على سلوك التآكل للحديد المقاوم للصداء في اللعاب الصناعي

الخلاصة :

قياسات الاستقطاب الكهروكيمياوية استعملت في هذه الدراسة لبيان تأثير اللاجك أسيد على سلوك التآكل البايولوجي لسبيكة الحديد المقاوم للصدأ من (316 L SS) نوع في مشبهات محاليل الجسم (سائل رنكر) الذي استخدم كمحلول الكتروليتي تجرى فيه اختبارات التآكل درجة حرارة لخلية الاستقطاب تم تثبيتها على درجة ^{O}C

±1 37 بواسطة حمام مائي لمحاكاة درجة حرارة الجسم البشري النتائج المستخلصة من سلوك التآكل المتحرى عنة بالقياسات الكهروكيمياوية بينت إن كثافة تيار التاكل لنماذج سبيكة الحديد المقاوم للصدأ (316 L SS) المضاف إليها اللاجك أسيد اقل بكثير من النماذج التي لم يضاف إليها اللاجك في محلول رنكر.

Key word :

Corrosion of implant inhibition corrosion of (316 L SS**), Ellagic acid, biomaterial.**

1. Introduction:

The corrosion resistance of stainless steels is well known in a wide range of media (Avesta SheYeld , 1999) , but many studies exist concerning release rates of alloy constituents from stainless steels into body fluids . Stainless steels may come into contact with a wide range of body fluids, including e.g. sweat, saliva , blood/plasma/lymphatic fluids, synovial fluids, respiratory tract fluids, and gastric juice . Reliable information on metal release rates is invaluable when assessing the potential for risk of adverse effects arising from exposure to metal constituents of stainless. (G. Herting, 2005), (I. Odnevall Wallinder, 2002) .This study is attempt to inhibit the corrosion of (316 L SS) in simulated body fluid by using Ellagic acid which a naturally occurring phenolic constituent in certain fruits and nuts.

Research in the past decade confirms that Ellagic acid markedly inhibits the ability of other chemicals to cause mutations in bacteria. Ellagic acid from red raspberries has proven as an effective anti mutagen and anti carcinogen as well as an inhibitor of cancer and intioxidant and antiatherosclerosis. (Stephen T. Talcott , 2002). Ellagic acid has been found to occur naturally in 46 different foods, with the red raspberry having been identified as having the highest natural content. Ellagic acid is a phenolic compound found in plants in the form of hydrolysable tannins called ellagitannins. Ellagitannins are esters of glucose with hexahydroxydiphenic acid ; when hydrolyzed, they yield Ellagic acid, the dilactone of hexahydroxydiphenic acid. Ellagic acid is a very stable compound and is readily absorbed through the gastrointestinal system in mammals, including humans . (Joon B. Park , 2002) .

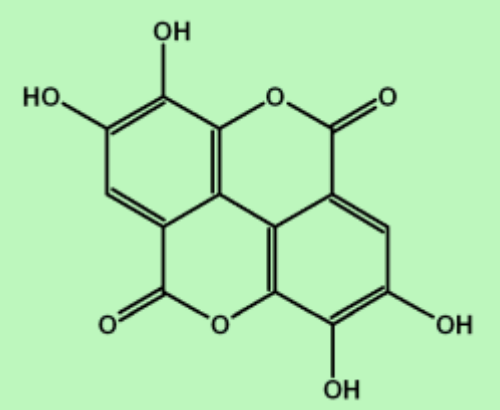
The Ellagic acid is rapid absorption and subsequent metabolism . (T.M.Sridar, 2003) . The absorption of Ellagic acid occurred mostly within two hours after oral administration and mor than 53% of the orally administered of Ellagic acid remained in the gastrointestinal tract at 24h.(M. Sivakumar, Eng. Perf. 3 ,744, 1994). The Ellagic acid has reportly strong affinity for protein and poor absorption in small animals, further studies to investigate whether the presence of free Ellagic acid in human plasma may be due to its releas from the hydrolysis of ellagitannine,facilitated by physiological pH and/or gut microflora action. (T.M.Sridar , 2003).Corrosion is the major problem affecting the service life of orthopedic implants.

There are numbers of ways to reduce corrosion, altering the environment using addition of inhibitors. Metals and alloys are used in restoration of anatomical structures for centuries owing to their superior mechanical properties. However, the degradation of most metals implanted in the human body has narrowed the choice of clinically usable metals and alloys to mainly-stainless steels, cobalt-chromium and titanium and its alloys . (M. Sivakumar, Sci. Lett. 13 ,142 ,1994), (O.E.M. Pholer, 1986). These metallic devices are unique that they are exposed to living cells, tissues and biological fluids which are not only dynamic but are also a hostile environment for the survival of the implant. (ASM , Metal Handbook , 1985) , (Annual Book of ASTM Standard , 1980). Type (316 L SS) are widely used for implantation purposes in orthopaedic surgery owing to their corrosion resistance, mechanical properties and low cost. However, clinical experience has shown that they are susceptible to localised corrosion in the human body causing the release of metal ions into the tissues surrounding the implants. (Murtdha . A. siyah , 2009) .

2. Experimental work :

2-1 Chemicals:

Ellagic acid used in this work as inhibitor, which obtained from sigma chemical-USA **(**MW: 302.19 Formula: $C_{14}H_6C_{8.)}$ And the chemical formula of acid was show in fig. 1 .



Fig(1): Chemical formula of Ellagic acid .

Analytical grad (CDH, NEW Delhi, Indi) salt were used to prepare the electrolyte where dissolved in double deioninzed water . Chemical composition of simulated body fluid(Ringer's solution) listed in Table 1 .

Table 1 Chemical composition of Ringer's solution .
(K. R. Wheeler, 1971) , (A.T. Kuhn , 1988).

Chemical Reagents	Weight (g/L)
NaCl	9.00
KCl	0.43
$CaCl_2$	0.24
$NaHCO_3$	0.20

2.2 Material:

The material used in this work was austenitic (316 L SS) . Analaytsis of this material was carried out using (XRF) X-MET 3000 TX from oxford instruments, England in Ministry of Science and Technology (Iraq). Table 2 shows the nominal and the analytical chemical compositions of (316 L SS) used in this work.

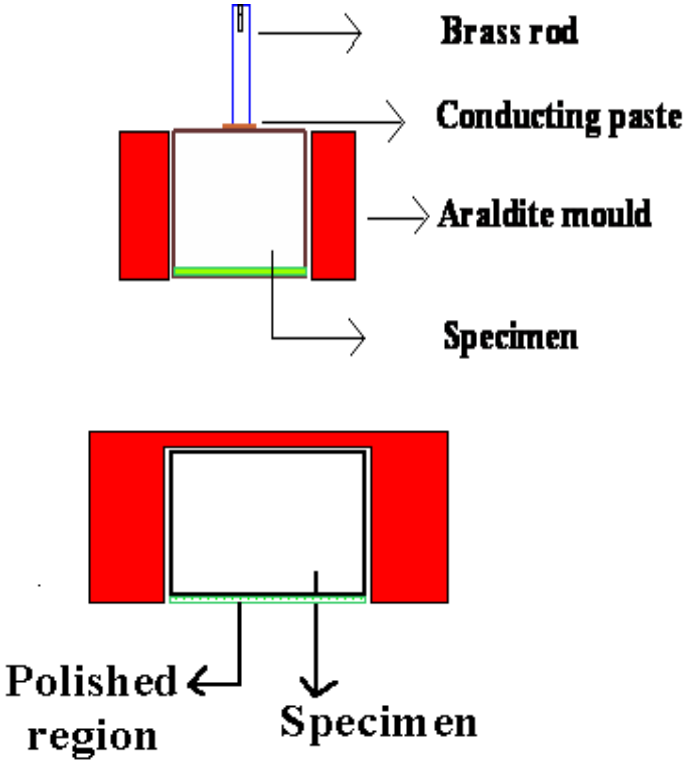
Table 2 A nominal and analytical chemical composition of (316 L SS)

Element wt % Alloy	Fe	N	Mo	S	P	Si	Mn	Ni	Cr	C
Actual Value	Rem.	0.10 Max	2-3	0.03 Max	0.045 Max	0.75 Max	2.00 Max	10-14	16-18	0.03 Max
Analytical	Rem.	0.08	2.2	0.01	0.02	0.67	1.61	11.81	16.18	0.027

2.2.1. Preparation of Sample :

Surface condition of specimen plays an important role in corrosion resistance, hence, it is necessary to prepare uniform surface and requires careful specimen preparation. The specimens were cut out in dimensions of (10×10 mm) for electrochemical tests and (20×20 mm) and 2 mm thick for corrosion test see the figure (2). The shaped specimens were molded using fast cold setting material up to 20 cm thick leaving the topside of the specimen exposed. The mounted specimens were allowed to set for half an hour and care was taken to ensure that the mould does not contain any cracks or bubbles at the mould / specimen interface. For electrochemical studies, suitable provision was made on the other side for electrical contact. The schematic diagram of the molded specimen for microstructure evaluation and electrochemical tests. The mounted specimens were ground with SiC emery papers in sequence on 120, 180, 220, 320, 500, 800, 1000, and 1200 grit to get flat and scratch-free surface. The specimens were polished using polish cloth and alpha alumina 0.3μm and washed with distilled water. The polished specimens were degreased with acetone trichloroethylene and cleaned in the same solution. The degreased specimens were washed with deionized water, dried and kept in a dissector over a silica gel pad and used for microstructure evolution and electrochemical investigation.

Kroll's reagent containing 45ml of Glycerol, 15 ml of HNO_3 and 30 ml of HCl was used for etching the surface to optical observation with time of exposure 30 second (Murtdha .A.siyah , 2009) .



Fig(2): The schematic diagram of the molded specimen for microstructure evaluation and electrochemical tests.

2.2.2. Microstructure Evolution:

The micro structural evolution was investigated by means of optical microscopy using (Nikon Type 120, Japan optical microscope), provided with digital camera type DXM 1200 F. The micrographes were analyzed through Nikon ACT-version 2.62, 2000 soft. The microstructure obtained of the material used is shown in fig. 3 . The microstructure of (316 L SS) consists of solid solution (γ) which has constitution of nickel and chromium as substantial components dissolved in the matrix. This microstructure description is also present in the ASTM standard. (ASM, Metal Handbook, 1985). This grade of austenitic (316 L SS) contains 16% or more chromium, a ferrite-stabilizing elements, and sufficient austenite-stabilizing elements, such as carbon, nitrogen, nickel and manganese, to render austenite stable at room temperature.

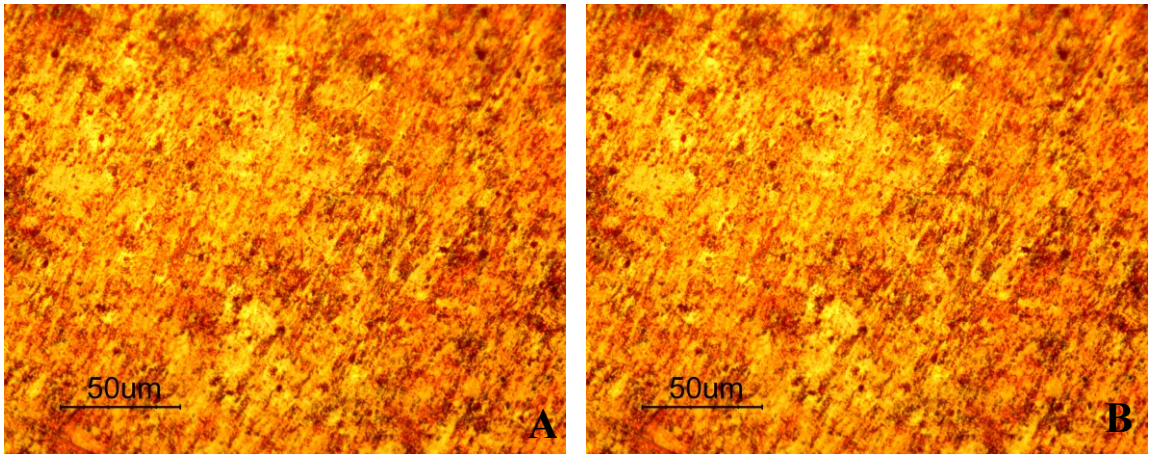


Fig (3): Optical micrograph of the as received (316 L SS) A (500X), B (1000X).

2.2.3. Electrochemical Measurement:

Polarization experiments were performed in (BANK ELECTRONIK) (Germany) with electrochemical cell with three electrodes: auxiliary electrode (pt electrode), working electrode (316 L SS) and aluggin capillary for connection with an SCE reference electrode. All experiments performed in f (Ringers solution) at pH.7.4 and temperature 37 ± 1 º C to simulate the human body condition.

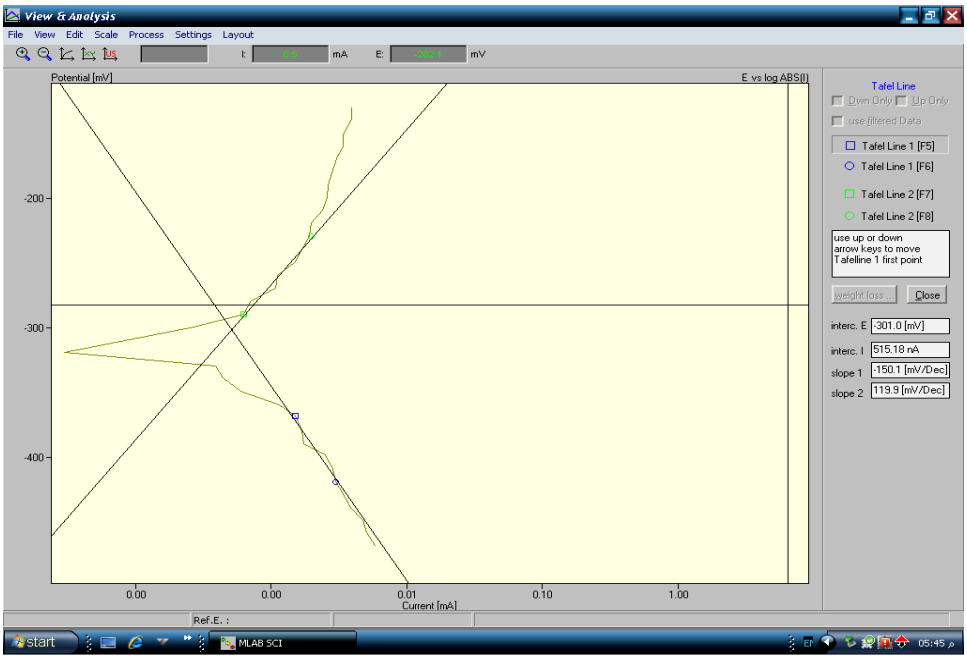
Electrochemical measurements were carried out with a potentiostat by electrochemical software at a scan rate 10mV/min and polarization experiments were stated when the rate at which open circuit potential (OCP) changed was less and more 200mV.

The main result obtained were expressed in terms of the corrosion potential (Ecoor) and current density (icorr) in addition to measure the Tafel slope.

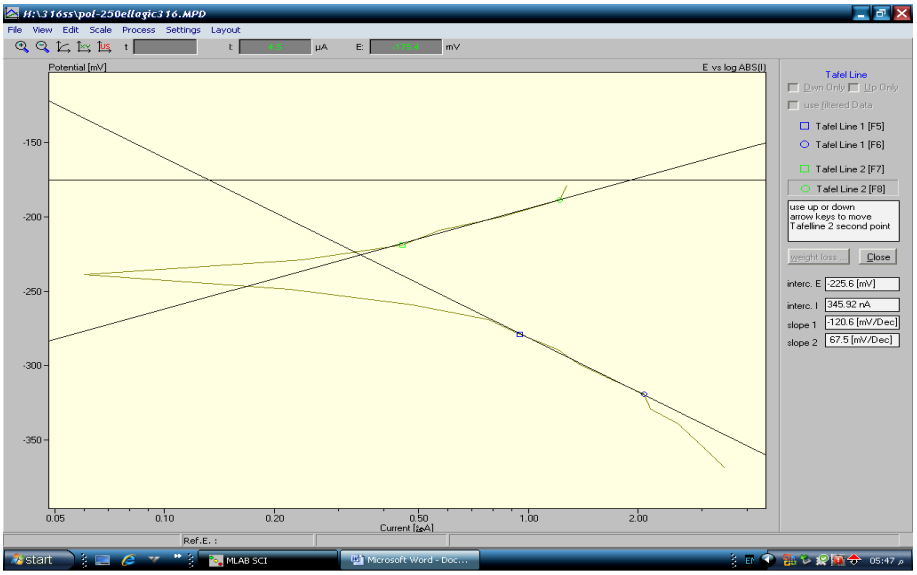
3. Results And Discussion :

The electrochemical parameters determined from the polarization curves (Fig. 4, 5, 6, 7 and 8) are given in Table 3 . The figures show cathodic and anodic polarization curves of specimens in the Ringer Solution mixed with Ellagic at different concentration . The fig. 9 show the effect of Ellagic contraction on corrosion behavior of (316 L SS) in the Ringer solution compared to that for specimen immersed in the Ringer without Ellagic The corrosion current density of (316 L SS)

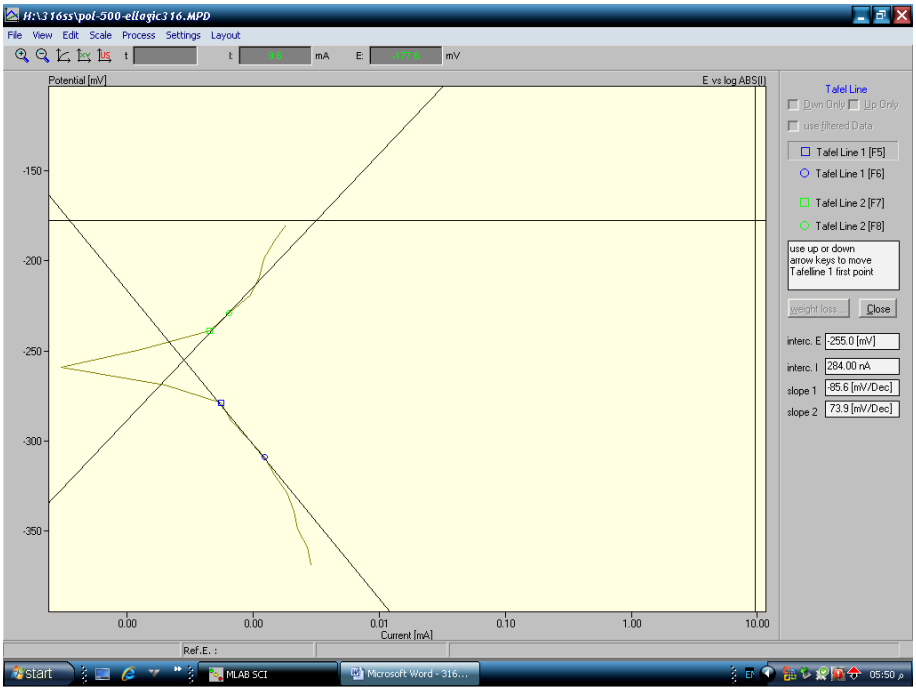
decrease with increasing concentration of Ellagic, indicating Ellagic revealed a good corrosion inhibition .



Fig(4): Tafel fit of Potentiodynamic Polarization of (316 L SS) in Ringer Solution without concentration of Ellagic.



Fig(5) Tafel fit of Potentiodynamic Polarization of (316 L SS) in Ringer Solution with (0.025) gm/L concentration of Ellagic.



Fig(6): Tafel fit of Potentiodynamic Polarization of (316 L SS) in Ringer Solution with (0.050) gm/L concentration of Ellagic.

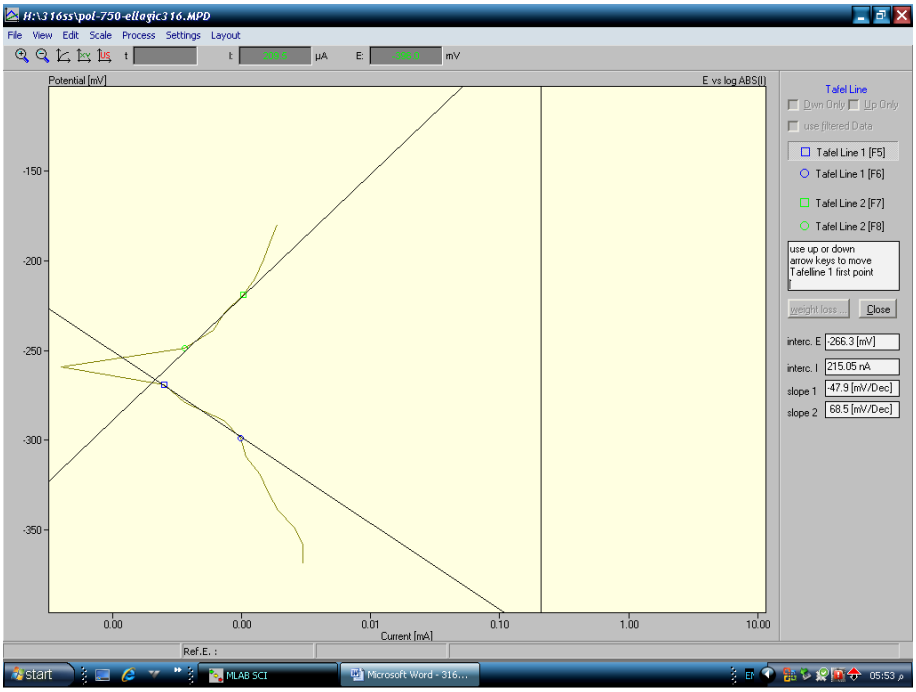


Fig. 7 Tafel fit of Potentiodynamic Polarization of (316 L SS) in Ringer Solution with (0.075) gm/L concentration of Ellagic.

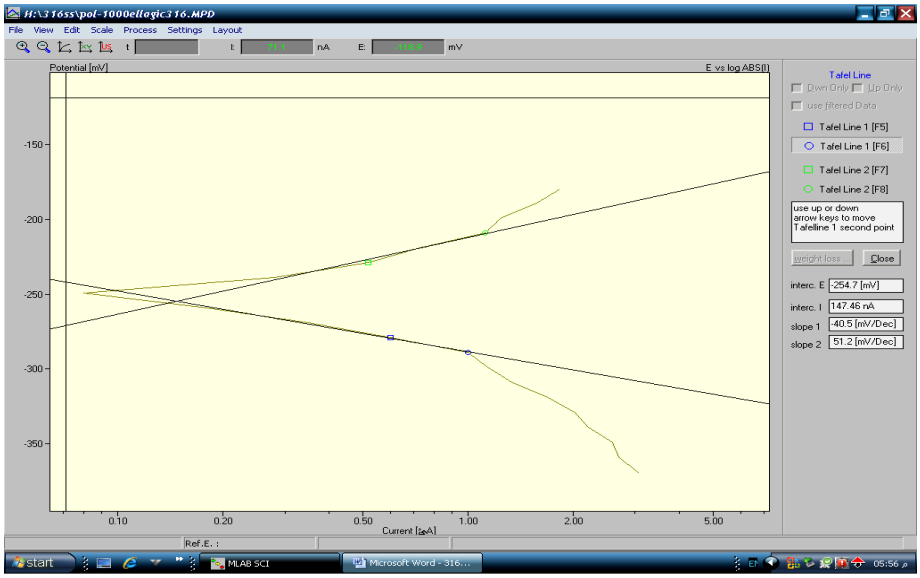
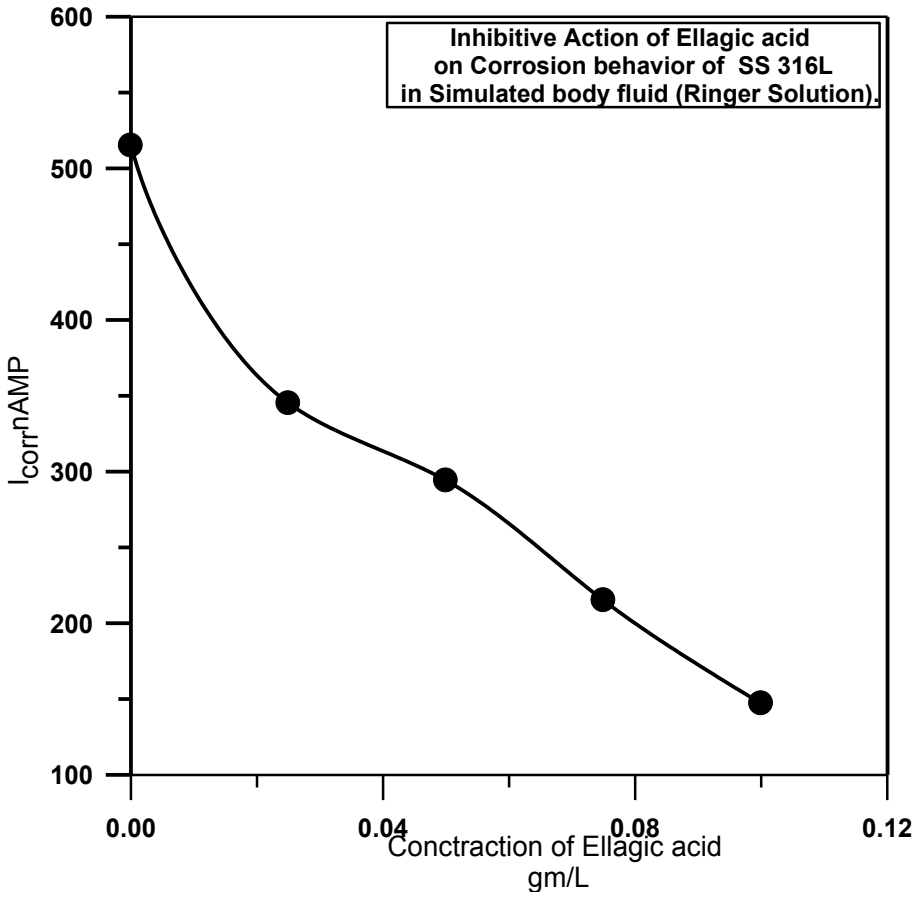


Fig.(8): Tafel fit of Potentiodynamic Polarization of (316 L SS) in Ringer Solution with (0.1) gm/L concentration of Ellagic.



Fig(9): Effect addition of Ellagic acid on Corrosion current density of (316 L SS) in simulated body solution (Ringer Solution).

Table 3 the effect of addition Ellagic acid on the value of current density and M.P.Y

Concentration of Ellagic acid (gm\L)	Icorr μ amp	M.P.Y Mil per year ZX
0	0.515	0.226
0.025	0.345	0.151
0.05	0.284	0.124
0.075	0.215	0.094
0.1	0.147	0.064

4. Conclusion:

1. The Ellagic acid can be used as an inhibitor for (316 L SS) in simulated human body fluid dissolution .

2. The presence of Ellagic acid shift the Ecorr toward noble direction compared with the absence of acid.

3. The presence of Ellagic acid shift Icorr toward less value compared to those without Ellagic, the effects of Ellagic are not only the protection of (316 L SS) . From chloride attack but also the suppression of dissolution of 316 L SS ions via

4. Inhibitive action at. Ellagic acid accurse through producing oregano metallic complexes.

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