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Study of ellagic acid inhibitive on corrosion behavior of carbon steel

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ABSTRACT

The purpose of the present study was to optimize the process for production of Ellagic acid (EA) from grapes seed. The final filtered were determined using FTIR and GC-MS. In addition, the effect of EA as inhibitor of biocorrosion of carbon steel N-80 in artificial saliva as media of electrolyte were investigated. The temperature of polarization test cell was maintained at 37±1^{o}C by thermo-stated water bath to simulate the human body temperature. The corrosion of N-80 was suppressed in solutions containing EA which are added in different concentrations. The corrosion behavior investigated by electrochemical measurement. The result showed the density of corrosion current of N-80 specimens in solution of artificial saliva which containing EA was much lower than the values obtained of artificial saliva solution without ellagic acid.

Keywords: Ellagic acid, Biocorrosion, Inhibition, Carbon steel.

INTRODUCTION

Ellagic acid is a polyphenol antioxidant found in numerous fruit and vegetables including raspberries, strawberries, cranberries, pomegranates and other plant food. The ant proliferative and antioxidant properties of ellagic acid have spurred preliminary research into the potential health benefits of ellagic acid consumption [1, 2]. Ellagic acid has substantial potential for decreasing the risk of tumorigenicity. It is an antioxidant as effective as or better then α tocopherol or tertiary butylhydroxyanisole (TBA) and it shows inhibitory activity against lipid peroxidation [3,4]. Ellagic acid controls hemorrhage in animals and humans [5]. It is also effective for treatment of ulcer and gastrointestinal disorder such as constipation, heartburn, non-ulcer dyspepsia and esophagitis [6]. The EA has strong affinity for protein in small animals. Further studies investigated the presence of free EA in human plasma may be due to its release from the hydrolysis of ellagitannine [7]. Corrosion is the major problem affecting the service life of orthopedic implants. There are a number of ways to reduce the 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. In addition, the degradation of most metals implanted in the human body which had narrowed the choice of clinically usable metals and alloys to mainly stainless steels, cobalt, chromium, titanium and its alloys [8,9]. These metals devices are unique and exposed to living cells, tissues and biological fluids which are not only dynamic but are also a hostile environment for survival of the implant [9, 10].

Carbon steel contains 0.04-1.70% carbon and widely used in many applications, especially infrastructure construction, reservoirs and other equipments in industrial plants. However, clinical experience has shown that they are susceptible to localized corrosion in the human body causing the release of metal ions into tissues surrounding the implants with several incidences of failures [11-13].

MATERIALS AND METHODS

1- The researcher prepared EA extracted by snapped 20gm of dry grinded grapes seed and addition of 120mL of ethyl alcohol (99.98%) which has been soaking for 16h, then filtrate the extracted, this process was repeated for four times, Placed the filtrate in a rotary evaporator.
2-Use Ringer solution as a liquid imitator of body fluid in order to simulate the process of corrosion of the alloy in body solution, as it was installed all the function of temperature and pH of the liquid.
3-Electrolysis process was performed by using a device (wenking-m-lab., Germany), which contain three electrodes:
A. Platinum electrode as counter elec.
B. A saturated calomel electrode (SCE) as reference electrode.
C. Working electrode which carries the measured substance. As shown in figure 1.
4-Measurement of samples in a liquid body (artificial-saliva industrial-ringer solution) at $37\pm1^{o}C$, pH 6.8 and immersed the electrodes in thermostatic electrolyte solution due to study the corrosion process by calculating the corrosion potential and corrosion current for a period of time.
5-Add (0.4, 0.6, 0.8, 1.0) mL of extracted individually after diluted by 1L of ringer solution.
6- Chemical analysis of carbon steel N-80 was carried out from south oil company, Basra, Iraq.

Table 1 indicates Chemical composition of carbon steel alloy N-80 and table 2 gives Chemical composition of modified artificial Saliva in Dental .Surface condition of specimen plays an important role in corrosion resistance, therefore, it is necessary to prepare uniform surface and requires careful specimen preparation. The sample was cut out in dimensions of 10x10mm for electrochemical test and 20x20mm and thickness 2mm for corrosion test. 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 electrochemical investigation.

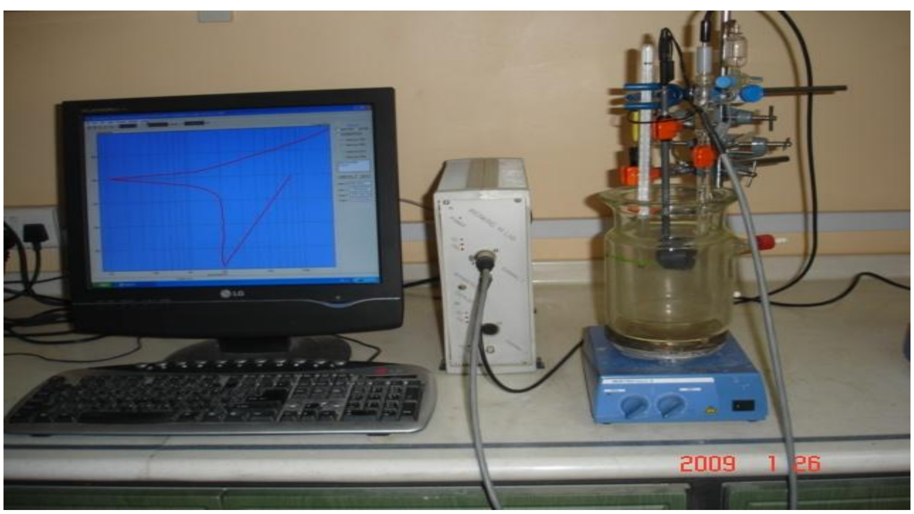


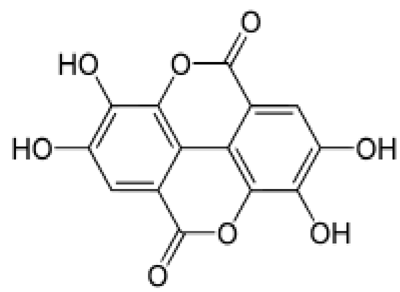
Fig. 1: Electrochemical cell

Table 1: Chemical composition of carbon steel alloy N-80.

Element N-80 / Alloy	C	Cu	Ni	Mn	Si	Mo	W	Fe
Actual Value%	0.022	0.21	0.07	0.85	0.729	0.01	0.041	98.09

RESULTS AND DISCUSSION

The basic structure of EA compound figure 2 can be determined by the spectral location of their IR absorption. Figure 3 shows IR spectrum of the extracted EA exhibit broad band in the range (3250-3500) cm^{-1} assignable to intermolecular hydrogen bonding and stretching vibration of hydroxyl group while the band observed at 1739cm^{-1} due to carbonyl group of the lactones. Significant for the identification of the source of absorption at 1615cm^{-1} and 1452cm^{-1} corresponds to the stretching vibration of the (C=C) aromatic ring. The band position at (803-1049) cm^{-1} indicates the out of plane bonding of the (C-C) aromatic ring.



2, 3, 7, 8-Tetrahydroxy-chromeno [5, 4, 3-cde] chromene-5, 10-dione
Fig. 2: Chemical structure of ellagic acid

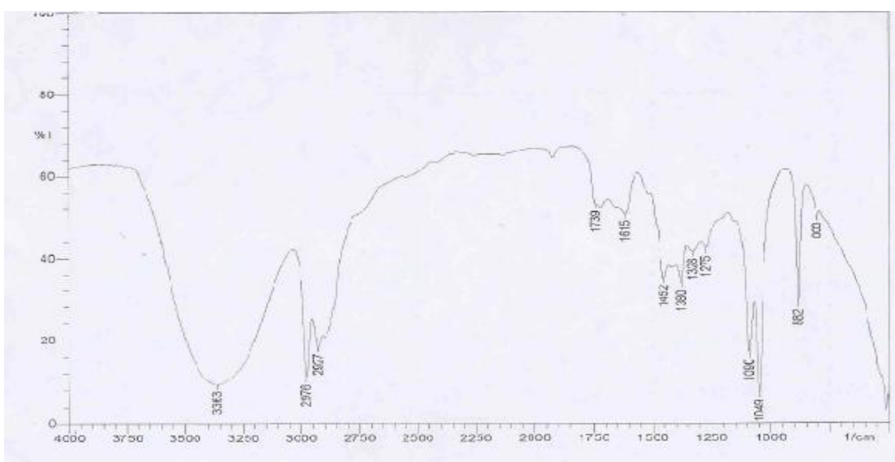


Fig. 3: FT-IR Spectrum of extracted EA

Figures 4 and 5 were identified as free ellagic acid and trimethyl ellagic acid respectively, on the basis of its retention time. Ellagic acid was confirmed by its *m/z* (300, 284, 257, 227, and 185) [14, 15].

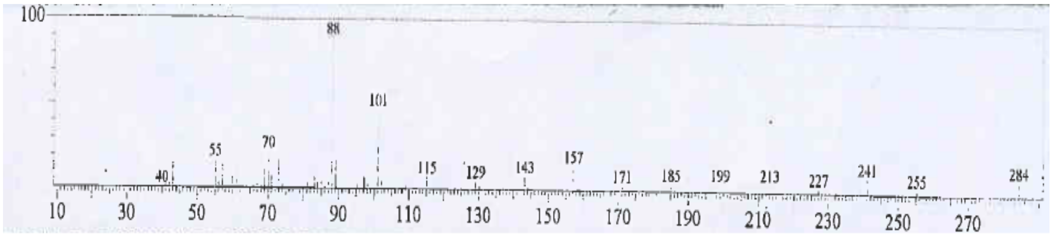


Fig. 4: GC-MS chromatogram of extracted EA

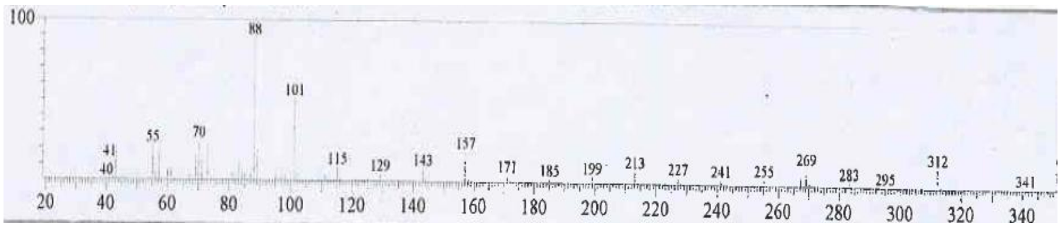


Fig. 5: GC-MS chromatogram of trimethyl ellagic acid

Electrochemical behavior in the body solution [artificial-artificial saliva as shown in table 2 shows that the corrosion current is 43.81µA and corrosion potential -547.5mV without adding extracted as in figure 6, which uses point review of the study inhibitory effect on biological corrosion behavior of N-80.

Table 2: Chemical composition of modified artificial Saliva in Dental.

no.	CONSTITUENT	WEIGHT (gm/l)
1	NaCl	0.70
2	KCl	1.20
3	KSCN	0.33
4	$NaHCO_3$	1.50
5	Na_2HPO_4	0.26
6	KH_2PO_4	0.20
7	Urea	0.13

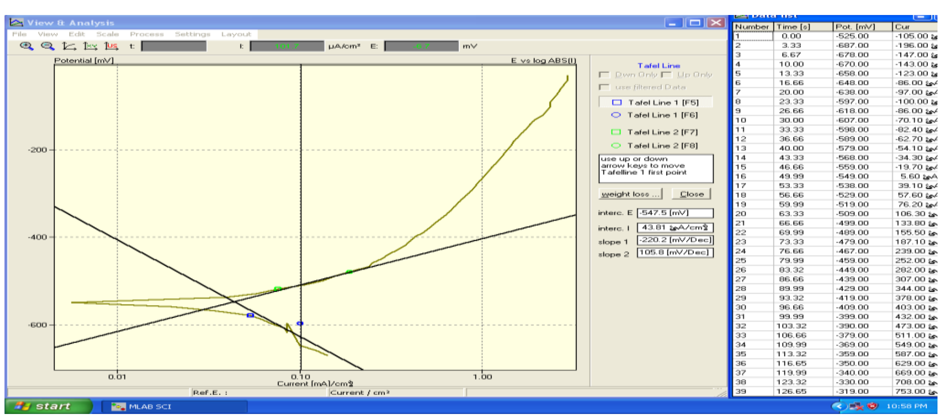


Fig. 6: Corrosion rate of N-80 without inhibition

In figure 7 notice a difference in the corrosion current is 32.09µA and corrosion potential -588.2mV after adding 0.4mL of extracted, so the present study deals with the effect of corrosion current inhibition by add EA extracted. Which are formed free ions lead to stable complexes, therefore the researcher see there is inhibition of corrosion current.

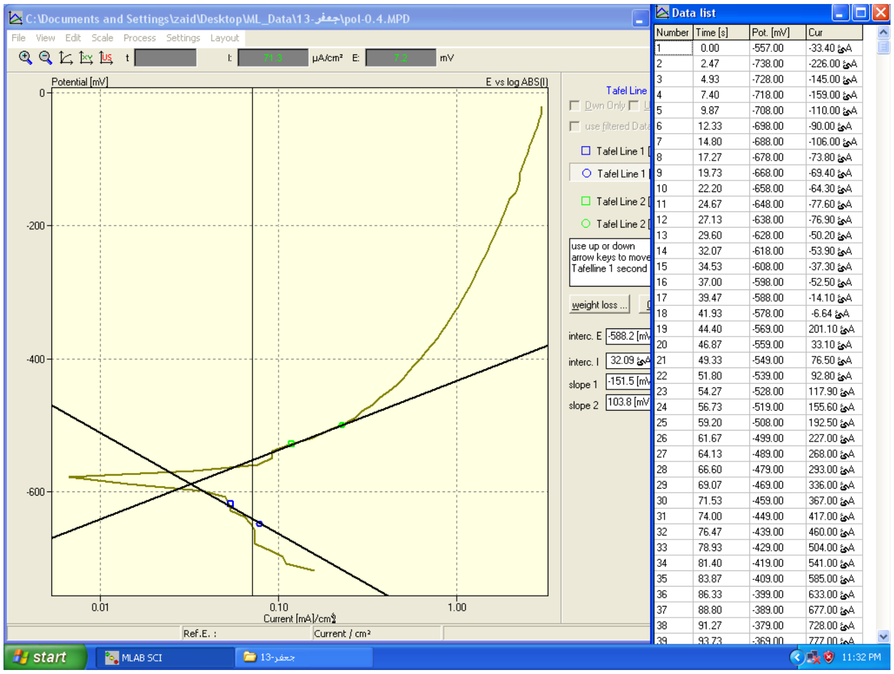


Fig. 7: Corrosion rate of N-80 by add 0.4mL of extracted EA

In figure 8 notice a difference in the corrosion current is 22.66µA and corrosion potential -586.2mV after adding 0.6mL of extracted, so the present study deals with the effect of corrosion current inhibition by add EA extracted. Which are formed free ions lead to stable complexes, therefore the researcher see there is inhibition of corrosion current.

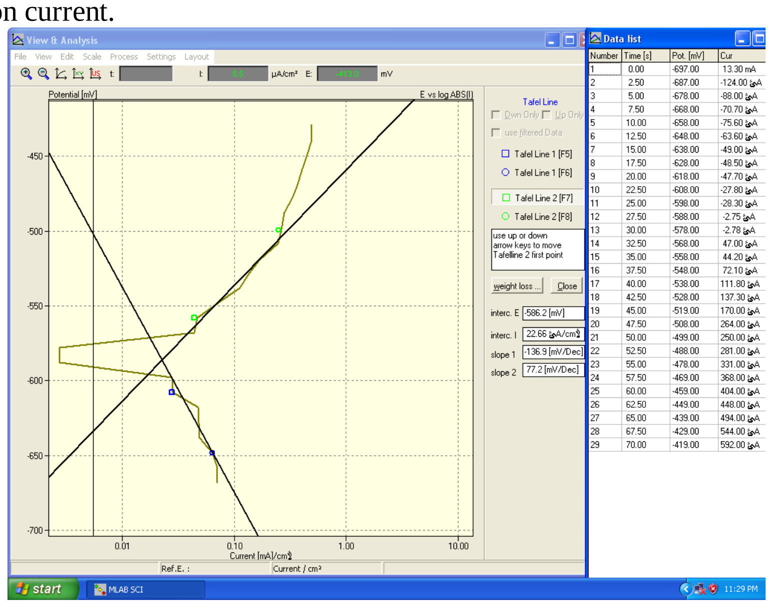


Fig. 8: Corrosion rate of N-80 by add 0.6mL of extracted EA

After add 0.8mL of EA extracted which lead to reduce of corrosion current to19.85 µA due to formation of stable complexes as shown in figure 9.

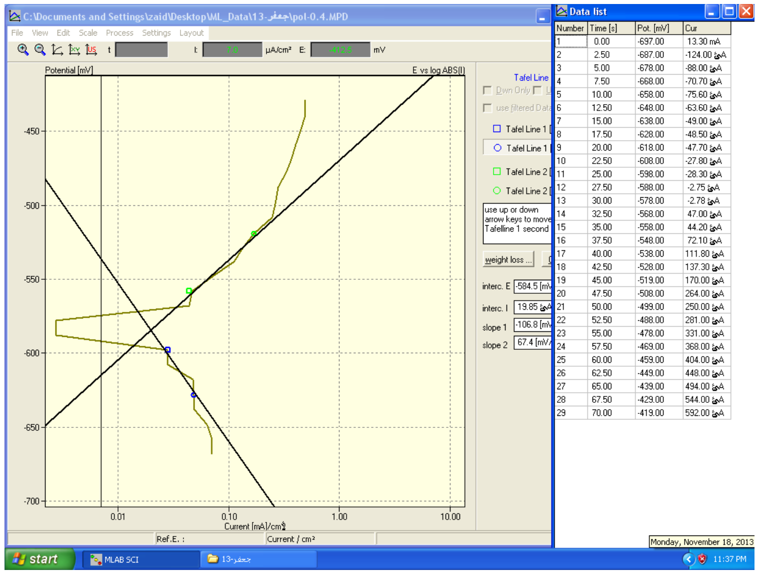


Fig. 9: Corrosion rate of N-80 by add 0.8mL of extracted EA

Finally, figure 10 show a difference in the corrosion current is 18.23µA and corrosion potential **-**586.2mV after adding 1.0mL of extracted, so the present study deals with the effect of corrosion current inhibition by add extracted EA. Which are formed free ions lead to stable complexes, therefore the researcher see there is inhibition of corrosion current. The corrosion current density of N-80 decrease with increasing of EA concentrations, indicating EA revealed a good corrosion inhibition. This is clear in the figure 11.

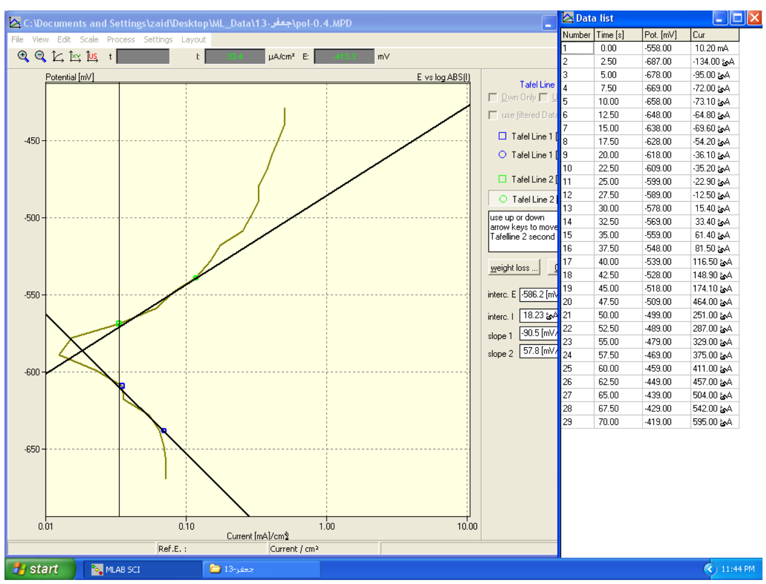


Fig. 10: Corrosion rate of N-80 by add 1.0mL of extracted EA

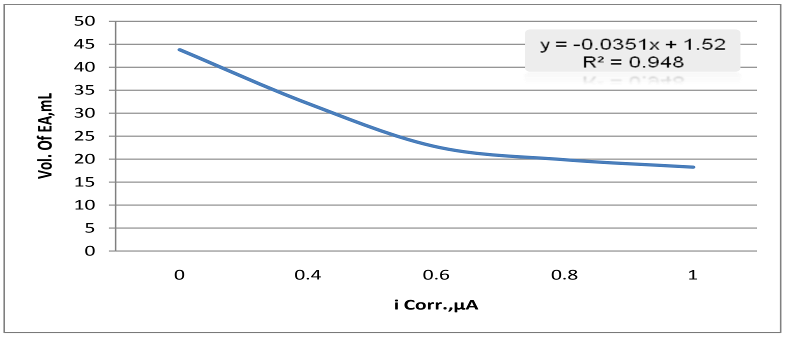


Fig. 11: The relation between corrosion current and conc. of extracted EA

APPLICATIONS

The corrosion behavior is investigated by electrochemical measurement. The result showed the density of corrosion current of N-80 specimens in solution of artificial saliva which containing EA was much lower than the values obtained of artificial saliva solution without ellagic acid. This study is useful to prevent biocorrosion through Ellagic acid.

CONCLUSIONS

The extraction conditions have a significant effect on the EA extraction yield. The increasing concentrations of EA lead to decrease of density of corrosion current for N-80.

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