CORROSION RESISTANCE OF METALS IN SIMULATED

RINGER SOLUTION-A

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Corrosion resistance of three metals namely mild steel, 22 carat gold and 18 carat gold in Ringer Solution –A has been evaluated by polarization study. The corrosion resistance of metals in simulated Ringer Solution-A is follows; 22 carat gold > 18 carat gold > mild steel. This is due to the variation in composition of various types of gold

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INTRODUCTION

Recently, the development of biodegradable implants has attracted much attention in some biomedical applications where just require a temporary implant.[1,2] This kind of implants would be dissolved, absorbed or excreted gradually by human body after the fulfilment of their purpose at the site of implantation. Since then, biodegradable implants possess the essential potential to reduce/overcome the limitations posed by the permanent implant, such as elastic modulus mismatches between surrounding tissue and the implant, physical irritation or chromic inflammation etc.[3] Furthermore, such a biodegradable implant is expected to remove the need for a second surgical intervention to remove the implants after the successful treatment. This should certainly be deemed beneficial to patients.[1] Currently, the available biodegradable implants are primarily polymer-based. However, the insufficient mechanical strength, a drawback of their intrinsic mechanical properties, has limited their wide applications.[4,5] Thus, other biodegradable implants with sufficient mechanical properties are required urgently to be developed.

Corrosion resistance of meals and alloys in various body fluids such as artificial saliva,[6,7,8] artificial sweat,[9,10,11] blood plasma,[12,13,14] Artificial urine[15,16,17] and Ringer solution[18,19,20] has been investigated. The present work is undertaken to investigate the corrosion resistance of three metals namely, mild steel, 22 carat gold and 18 carat gold in Ringer Solution-A by polarization study.

Usually corrosion behavior metals and alloys have been studied in Ringer solution-A (RSA) whose composition[18,19,20] is given in Table 1.

Table 1. Composition of Ringer Solution-A

Substance	Amount, g L^{-1}
NaCl	6
KCl	0.075
CaCl$_2$	0.1
NaHCO$_3$	0.1

Ringer's solution [18,19,20] is the name given to a solution of several salts dissolved in water for the purpose of creating an isotonic solution relative to the bodily fluids of an animal. Ringer's solution typically contains sodium chloride, potassium chloride, calcium chloride and sodium bicarbonate, with the latter used to balance the pH. Other additions can include chemical fuel sources for cells, including ATP and dextrose, as well as antibiotics and antifungal. Ringer's solution is frequently used in *in vitro* experiments on organs or tissues, such as in vitro muscle testing. The precise mix of ions can vary depending upon the taxon, with different recipes for birds, mammals, freshwater fish, marine fish, etc. It may also be used for therapeutic purposes, such as arthroscopic lavage in the case of arthritis. Ringer's solution is named after Sydney Ringer in 1882, who found out that solution per fusing a frog's heart must contain sodium, potassium and calcium salts in a definite proportion if it has to beat for long. Ringer's solution is frequently used in human medicine in the form of Lactated Ringer's solution, a solution used in physiological experiments. It contains sodium, potassium, calcium, and magnesium chlorides; sodium bicarbonate, dextrose, and water.

MATERIALS AND METHODS

Three metal specimens namely mild steel, 22 carat gold and 18 carat gold were used in the present study. The composition of 22 carat gold,[21] 18 carat gold[22] and mild steel[23] are given in Table 2, 3 and 4 respectively.

Usually the study is carried out at 37 °C.

Table 2. Composition of 22 carat gold

Gold	91.67%
Silver	5%
Copper	2%
Zinc	1.33%

Table 3. Composition of 18 carat gold

Gold	75%
Copper	5-15 %
Silver	10-20%

Table 4. Composition of mild steel

Sulphur	0.026%
Phosphorous (Max)	0.06%
Manganese	0.4%
Carbon	0.1%
Iron	Balance

POLARIZATION STUDY

Polarization studies were carried out in a CHI-Electrochemical workstation with impendence Model 660A. A three-electrode cell assembly was used. The working electrode was mild steel. A saturated calomel electrode (SCE) was the reference electrode and platinum was the counter electrode. From the polarization study, corrosion parameters such as corrosion potential (E_{corr}), corrosion current (I_{corr}) and Tafel slopes (anodic=b_a and cathodic=b_c) were calculated.

It is observed from the Figure, 2 that for 18 carat gold,
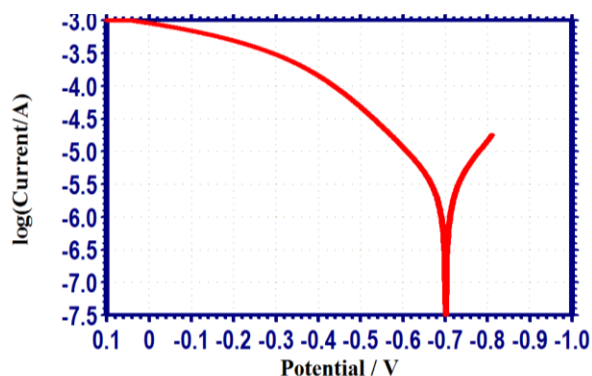
Figure 1. Polarization curve of mild steel immersed in Ringer solution A
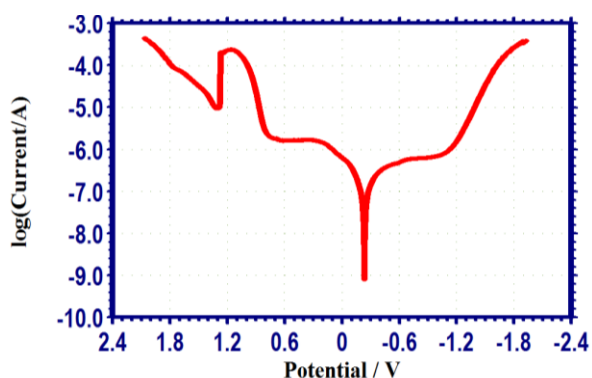
Figure 2. Polarization curve of 18 carat gold immersed in Ringer solution A
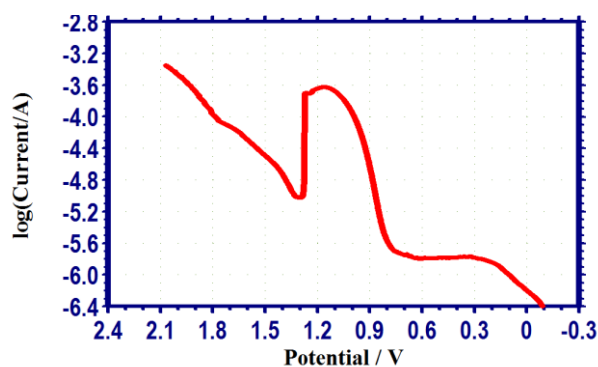
Figure2a. (Polarization curve of 18 carat gold immersed in Ringer solution A. Active passive region enlarged.
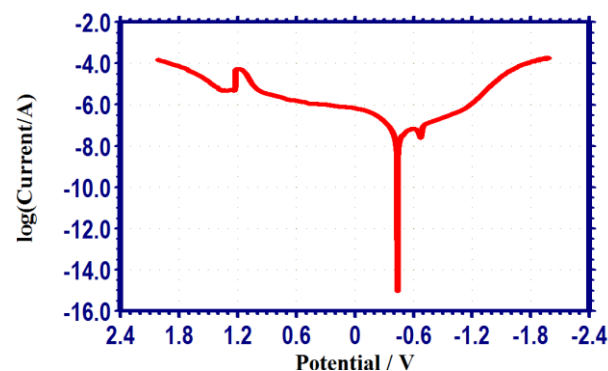
Figure 3. Polarization curve of 22 carat gold immersed in Ringer solution A
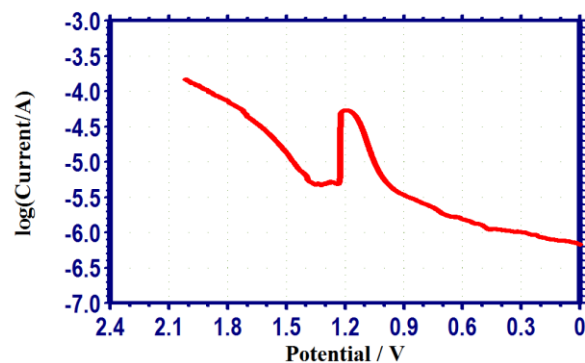
Figure 3a. Polarization curve of 22 carat gold immersed in Ringer solution A (active passive region enlarged.)

when the corrosion potential is shifted to noble side, that is from 241 mV to 760 mV, the corrosion remains constant. Afterwards as the corrosion potential is shifted to positive side, the passive film is broken and the corrosion current increases. When the corrosion potential 1253 mV is reached, the corrosion current sharply decreases. This is due to the fact a passive film is once again formed at this potential. When the potential is further increased to the positive side, the passive film is broken and the corrosion current increases. This is due to the presence of copper ions.

It is also observed that during cathodic polarization, the corrosion current remains constant in the potential range -1055 mV to -620 mV.

Table 5. Corrosion parameters of metals immersed in Simulated Ringer Solution-A obtained by potentiodynamic polarization study

System	E_{corr} mV vs SCE	b_c mV decade^{-1}	b_a mV decade^{-1}	LPR Ohm cm^2	I_{corr} A cm^{-2}
mild Steel	-701	125	143	10332	$2.803 \cdot 10^{-6}$
gold 18	-233	234	176	456194	$0.09563 \cdot 10^{-6}$
gold 22	-433	244	178	1279207	$0.03495 \cdot 10^{-6}$

During cathodic polarization, the corrosion current decrease sharply, when the potential changes from –1947 mV to –1061 mV.

It is observed from the Figure 3 that for 22 carat gold, as the corrosion potential is shifted to noble side, the corrosion current sharply decreases when, the corrosion potential is 1223 mV Vs ECE. A passive film is formed at this stage. Afterwards as the corrosion potential is shifted to noble side, the corrosion remains constant up to 1378 mV. Then the corrosion current increases.tha is, the passive film is stable in the potential range of 1223 mV to 1378 mV. This is due to the presence of copper ions.

RESULT AND DISCUSSION

Corrosion resistance of three metals namely mild steel, 22 carat gold, 18 carat gold in Ringer Solution-A has been investigated by polarization study.

Polarization study has been used to investigate the formation of protective film formed on the metal surface during corrosion process. If corrosion resistance increases, linear polarization (LPR) value increases. Corrosion current (I_{corr}) decreases.[24-33]

It is well known to everyone that mild steel should not be implanted in inside the body, because it will undergo corrosion due to the electrolytes present in body fluids. However in the present study, mild steel is used just for comparison.

The polarization curve of metals immersed in simulated Ringer solution-A are shown in Fig. 1. The corrosion parameters such as corrosion potential (E_{corr}), Tafel slopes (b_c=Cathodic; b_a=Anodic), linear polarization resistance (LPR) and the corrosion current (I_{corr}) are given in Table5.

When mild steel is immersed in SRAS, LPR value is 10332 Ω cm^2, corrosion current is $2.803 \cdot 10^{-6}$ Acm^{-2} and corrosion potential is –701 mV vs SCE.

When 18 carat gold is immersed in SRSA, LPR value (Fig 2) is 456194 Ω cm^2, corrosion current is 9.563×10^{-8} A cm^{-2} and corrosion potential is -233 mV vs SCE. It is observed LPR value increases and corrosion current value decreases. It is inferred that gold 18 is more corrosion resistant than mild steel. It is observed that the corrosion potential has shifted to the anodic side. This indicates that 18 Carat Gold is nobler than mild steel, due to the formation of passive film on the metal surface.

When 22 carat gold is immersed in SRSA, LPR value is 1279207 Ω cm^2, Corrosion current is $3.495 \cdot 10^{-8}$ A cm^{-2} and corrosion potential is -433 mV vs SCE. It is observed LPR

value increases and corrosion current value decreases. It is inferred that gold 22 is more corrosion resistant than mild steel and also 18 carat gold. It is observed that the corrosion potential is shifted to the anodic side. This indicates that 22 carat gold is nobler than mild steel, due to the formation of passive film on the metal surface.

Thus, polarization study leads to the conclusion that the decreasing order of corrosion resistance of metals under investigation, in simulated Ringer Solution-A is, 22 carat gold > 18 carat gold > mild steel

The above order may be explained by the fact that, there is variation in compositions of various types of gold.

CONCLUSION

Corrosion resistance of three metals namely, mild steel, 22 carat gold and 18 carat gold in SRSA has been evaluated by polarization study. The corrosion resistance of metals in Simulated Ringer Solution-A is follows: 22 carat gold > 18 carat gold > mild steel

This is due to the presence of variation in composition of various types of gold.

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