Corrosion Behavior of Copper-bearing Intrauterine Devices in the Presence of Proteins *In Vitro*

Bianmei Cao [a], Yudong Zheng [a],Tingfei Xi [a,b,c] and David Hui [d]

[a] School of Materials Science and Engineering, University of Science and Technology, Beijing, Beijing 100083, P.R. China

[b] National Institute for the Control of Pharmaceutical &Biological Products, Beijing 100050, P.R. China

[c] Shenzhen Institute of Peking University, Shenzhen city 518057, Guangdong province, P.R. China

[d] Dept of Mechanical Engineering, University of New Orleans, New Orleans, LA 70148, USA

Introduction

Intrauterine devices(IUDs) are effective, long-term reliable and reversible devices for contraceptive use worldwide[1]. However, the corrosion of copper in the presence of proteins is not well characterized. Here, the corrosion behavior of copper samples in different single-protein simulated uterine solutions was researched with open circuit potential, electrochemical impedance spectroscopy measurements and potentiodynamic polarization test.

Experimental

Materials

The material used is the copper tube of TCu220C-IUD product (Tianjin Medical Instrument Factory, China). For the electrochemical measurements, the copper tube was ultrasonically cleaned in ethanol for 10 min, immersed in hydrochloric acid for 30 s to remove the external oxide, and then washed with pure water. After dried, the copper tube was coated using insulating gel with a bare surface of 25 mm^2 as the working electrode exposed to solution.

Simulated uterine solution (SUS) is usually used to study the corrosion behavior. The compositions of SUS adopted at present are shown in Table 1[2].

Table 1 Compositions of simulated uterine solution (Concentration，g/L)

$NaHCO_3$	0.250
$NaH_2PO_4 \cdot 2H_2O$	0.072
Glucose	0.500
$CaCl_2$	0.167
KCl	0.224
NaCl	4.970

In addition, three human proteins (Sigma Chemical Co., U.S.A.), serum albumin (Batch 077K7585), gamma-globulin (Batch 027K7535) and hemoglobin (Batch 037K7635), were added into the solution separately to make three single-protein simulated uterine solutions with a concentration of 0.5g/L. Then, the pH values of above solutions were adjusted to 7.0 by adding diluted hydrochloric acid or sodium hydroxide solution.

Apparatus and Procedures

All the electrochemical measurements were performed with the electrochemical workstation (PGSTAT302N,

Netherlands), driven by GPES Version 4.9.007 and FRA Version 4.9.007 softwares for potentiodynamic polarization and electrochemical impedance spectroscopy (EIS) experiments, respectively.

Results and Discussion

The dependence of the OCP on electrode immersion time is shown in Fig.1. Initially, the OCP decreased rapidly, and then slowed down gradually to reach a stable value, which was corresponding to the corrosion potential. The addition of HSA moved the corrosion potential to negative values significantly, while hemoglobin and gamma-globulin showed slighter influence on the corrosion potential. The decline of corrosion potential suggested a reduction in the corrosion resistance of copper and an increase in dissolution rate of the original copper film after immersion.

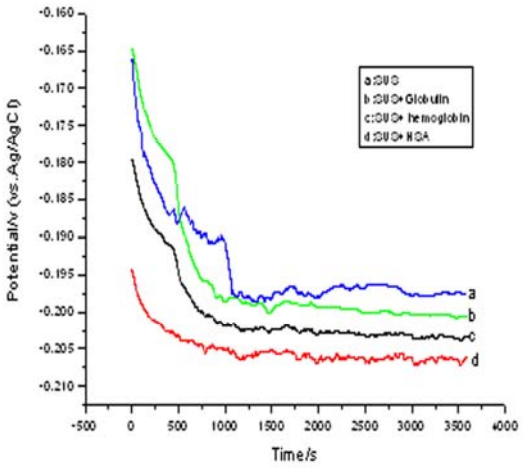

Fig.1 Dependence of the OCP of copper sample with time in: SUS; SUS + 0.5g/L HSA; SUS +0.5 g/L Hb; SUS + 0.5g/L globulin

Fig.2 shows polarization curves of Cu in SUS without and with proteins. All the proteins increased the anodic current above the OCP, thus accelerated corrosion rate of copper.

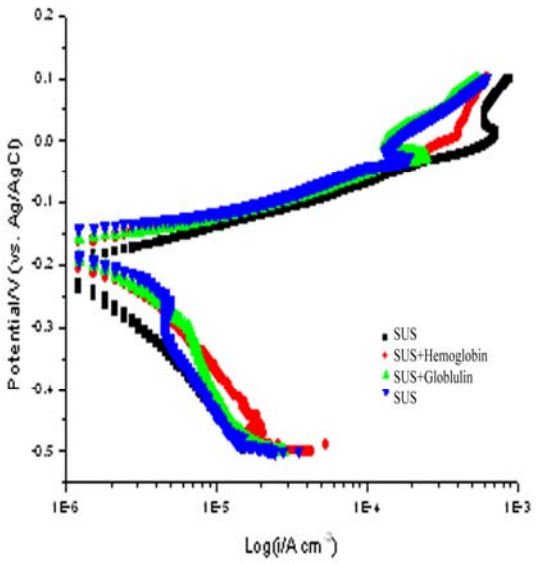

Fig.2 Polarization curves of Cu samples in: SUS; SUS + 0.5 g/L HSA; SUS + 0.5 g/L Hb; SUS + 0.5 g/L globulin recorded at a scan rate of 0.5 mV/s.

Conclusion

In vitro study, the copper corrosion of Cu-IUDs in simulated uterine solutions with different protein was investigated. The electrochemical results showed that the corrosion rate of the copper sample in SUS with HSA was higher than those with Hb, and the rate of the copper sample in SUS with Hb was higher than that with γ-globulin.

Acknowledgement

The work of D. Hui at UNO was partially funded by National Association of Corrosion Engineers, NACE

References

1. d'Arcangues C. Worldwide use of intrauterine devices for contraception. Contraception 2007; 75: 2-7.
2. Bastidas JM, Mora N, Cano E. Copper corrosion-simulated uterine solutions. Contraception, 61(2000) 395-399