Electrochemical Properties of Ti-Ag Alloys for Biomedical and Dental Applications

Hyung-Min Shim, Keun-Taek Oh, Kyoung-Nam Kim
Research Institute of Dental Materials, College of Dentistry, Yonsei University and Brain Korea 21 Project for Medical Science, Yonsei University[1], Department of 134, Shinchon-dong, Seodaemun-gu, Seoul, 120-752, South Korea

INTRODUCTION

Ti and Ti alloys have been widely applied to biomedical and dental fields and the demands for their applications have increased gradually in these fields. Ti and its alloys have been used as biomaterial because of their high corrosion resistance, low toxicity, low elastic modulus and low density. Their defects are low shear strength, low wear resistance, low weldability, low formability and low castability and hydrogen brittleness. The purpose of this study is to develop Ti-Ag alloys with high corrosion resistance, ion release property, weldability and biocompatibility and to evaluate the electrochemical properties of Ti-Ag alloys in an artificial saliva which is oral cavity simulated solution.

EXPERIMENTAL

Ti-Ag alloys were designed to increase Ag content from zero to 4.5 at% by 0.5 at%. The alloys were arc-melted, homogenized at 950℃ for 72 hours, hot-rolled to 2 mm in thickness, and finally solution heat-treated at 950℃ for 1 hour and quenched into water bath. Compositions of the alloys were investigated by EDS, C/S and O/N analyzers. Phase identification, hardness and agar overlay test were performed. To investigate the electrochemical properties, potentiodynamic and potentiostatic tests (open circuit potentials and current densities at –250, 0 and 250 mV (SCE)) were performed in artificial saliva, at 37 ℃. The data was treated statistically using student t test (confidence interval $p<0.05$).

RESULTS AND DISCUSSION

The purity of the alloys manufactured in this study was maintained above 99.9 %. It was considered because the impurities were little introduced into the alloys through the making process. As a result of phase analysis, α phase was stable up to 1.5 at% Ag, and α +β phases were coexisted above 2.0 at% Ag. This means that Ag was β phase stabilizing element in Ti-Ag alloys. In the range of 2.0~3.5 at% Ag addition, an acicular α grains was observed in β grain. As presented in Fig. 1, hardness values increased with Ag content, and the increments were about 100 % in the range of 2.0~3.0 at% Ag addition. It was thought that high increases of hardness values above 2.0 Ag content were due to the effects of solid solution strengthening and α to β phase transition. Ti-Ag alloys had higher corrosion resistance than Ti in anodic polarization curves presented in Fig. 2. These results mean that Ag addition to Ti can improve their corrosion resistance. Passive current densities in the anodic polarization curves were dependent on the chemical compositions of Ti-Ag alloys, however, they did not showed the linear relationship according to Ag contents. Ti-Ag alloys did not show pitting corrosion in artificial saliva. In the potentiostatic test, most of Ti-Ag alloys showed low current densities below 1 uA/cm^2 except for Ti0.5Ag, Ti4.0Ag and Ti2.0Ag, which showed the current density below 10 uA/cm^2. It was considered that Ag addition to Ti strengthened the passive film due to Ti dissolution induced by the difference of the electromotive force between Ti and Ag. In the agar overlay test performed to investigate the relationship between the electrochemical properties and biocompatibility, the cytotoxicity of Ti-Ag alloys and Ti was none or mild.

Conclusively, Ti-Ag alloys had higher mechanical properties and corrosion resistance than Ti, and demonstrated the similar toxicity to Ti. Therefore, it is thought that Ti-Ag alloys can be applied gradually to biomedical and dental fields.

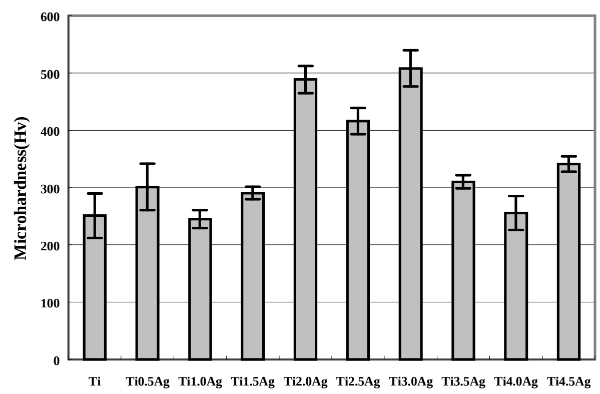

Fig. 1. Microhardness values of Ti-Ag alloys

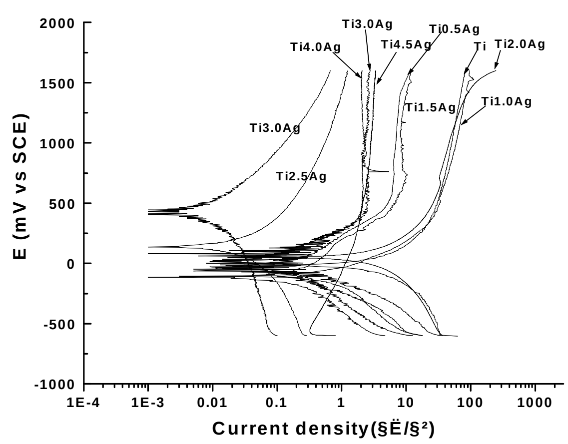

Fig. 2. Anodic polarization curves of Ti-Ag alloys in artificial saliva, at 37℃

ACKNOWLEDGEMENTS

This work was supported by Brain Korea 21 Project for Medical Science, Yonsei University in 2001.

REFERENCES

1. M.R. Plichta, H.I. Aaronson, and J.H. Perepezko, *Acta Metallurgica*, **26,** 1293 (1978).
2. Y. Takada, H. Nakajima, O. Okuno, and T. Okabe, *Dental Materials Journal*, **20,** 34 (2001).
3. M.G. Fontana, *Corrosion engineering*, pp. 482-504, Mcgraw-Hill, New York (1986).
4. M.J. Donachie, *Introduction to titanium and titanium alloys*, pp. 3-19, ASM, Ohio (1989).
5. E.W. Collings, *The physical metallurgy of titanium alloys*, pp. 39-74, ASM, Ohio (1984).