Improvement in photo-potential characteristics of TiO_2 electrode assembling to marine microbial fuel cell

S. Tamura*, M.Morita*, S. Motoda*,
S. Uematsu**, T. Shinohara***

*Tokyo University of Marine Science and Technology
2-1-6 Etchujima,Koto-ku, Tokyo 135-8533 Japan
**National Maritime Research Institute
6-38-1, Shinkawa, Mitaka, Tokyo 181-0004 Japan
***National Institute for Materials Science
1-2-1 Sengen, Tsukuba, Ibaraki 305-0047 Japan

Introduction

We have investigated the electrochemical characteristics of the marine microbial fuel cell(MFC) composed of biofilm covered stainless steel cathode and TiO_2 anode in seawater[1,2]. However, it is necessary to improve the photo-potential characteristics of electrodes for the practical application. For example, there is a method which enhances the electron transfer by the coatings of different metallic-oxide layer under or onto a TiO_2 film[3]. The present work attempted to improve the battery performance by using double layered TiO_2 anode electrode.

Experimental

Electrodes considered in the present study were TiO_2 coated Type 329J4L (UNS S32506) stainless steel disk (40mm in length, 1mm thickness). TiO_2 coating was accomplished by thermal spraying onto a base metal as primary film and squeegee printing as the second. TiO_2 powder which was purified to 99.9% was used for primary layer. The component of TiO_2 paste of secondary was as follows, TiO_2:15, H_2O:20 and alchols:65 in %. For the comparison, an electrode which was coated only by the squeegee method was also used. The thickness of both coatings was 120μm. In this work, one sample coated by the only squeegee printing is refer to single layered electrode, instead, another coated by the thermal spraying and squeegee printing is called double layered. TiO_2 coated stainless steel electrodes were immersed in the 1L artificial seawater and open circuit potential (OCP) was measured using potentiostat and saturated calomel electrode (SCE) as a reference electrode. The light source to irradiate onto the TiO_2 surface was 150W Xenon lamp in which a calibrated wave length was 250nm to 800nm. The quantity of light measured on the sample surface was 10.5mW/cm^2.

Results and Discussion

Fig. 1 shows the time variations of electrode potential of TiO_2 coated stainless steel (S.S.) samples under the irradiation of Xenon light. Before the irradiation, electrode potential for both samples was around -0.1V (SCE). After the irradiation, the electrode potentials of samples shifted down drastically and reached to -0.62V (SCE) for TiO_2 double layered sample and -0.5V(SCE) for TiO_2 single layered one in 20 min, respectively. After 20min, both samples kept stable potential over 2h. From the above, it showed that the photo-catalytic effect of double layered TiO_2 film is superior to the single layered film. It is assumed that thermal spraying TiO_2 film acts as intermediate-layer, therefore it promotes electron transfer between the base metal and top TiO_2 coatings interface. When double layered sample is composed to the MFC as an anode electrode, it results in power up of the battery.

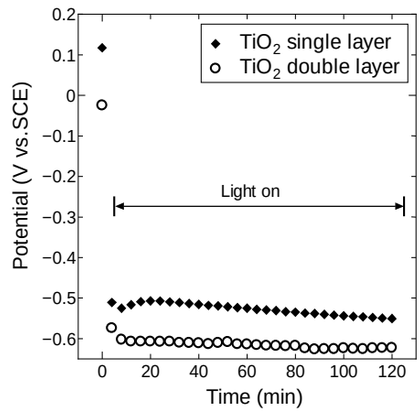

Fig.1 Time variations of electrode potential of TiO_2 coated stainless steel sample under the Xenon lamp irradiation for single or double layered electrode.

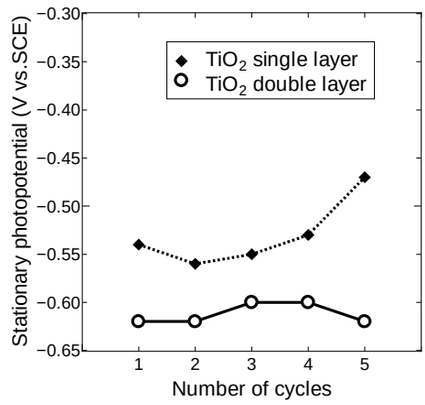

Fig.2 Cyclic degradation of photo-potential for TiO_2 anode electrode in 5cycle test at each runs of 2h irradiation.

Fig 2 shows the relationship between the stationary photo-potential and number of run cycles. The potential in Fig. 2 represents the cyclic stable mean potential in each irradiation test shown in Fig.1. The average potential from 60min to 120min regarded as the stable mean potential. For the double layer film, the potentials in each cycle kept lower than -0.60 V(SCE), although the single layer film, the potential rebounded to noble after 3 cycles. It is considered that the degradation caused by the anodic dissolution of base metal had occurred. The thermal spraying layer seemed to act as a sealing which suppresses the anodic dissolution of base metal without being resistance for charge transfer.

Conclusion

The present work has demonstrated that the double layered TiO_2 coating promotes the photo-catalytic effect by the sealing for the thermal spraying film as intermediate-layer. This phenomenon causes a power increase and high durability when it assembled into MFC as an anode.

References

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