Influence of ZrO_2 Coating on the Properties of Insoluble Anode for Cathodic Protection to Rebar Corrosion in Concrete

Hyun Young Chang[1], Ki Cheon Sohn[2], Seok Ju Hong[1], Young Sik Kim[2]

1. Power Engineering Research Institute, KOPEC, 360-9 Mabuk, Kusung, Yongin, Kyungi, 449-713, Korea
2. School of Materials Science and Engineering, Andong National University, 388 Songchun, Andong, Kyungbuk, 760-749, Korea

Rebar corrosion in concrete structure can be easily protected because pH of concrete is high. However, penetration of chloride into concrete, neutralization, and increased amount of salt sand et al. can corrode shortly the rebar in concrete construction. Therefore, appropriate protection should be applied for life extension of the construction, and thus electrochemical cathodic protection is usually used [1, 2, 3].

Properties of anode for cathodic protection need low overvoltage for oxygen evolution and high corrosion resistance. It is well known that DSA (Dimensionally Stable Anode) is the best anode till now [4, 5, 6, 7, 8]. DSA is mainly composed of RuO_2, IrO_2, ZrO_2, Co_2O_3, and ZrO_2, Ta_2O_5, TiO_2, MnO_2 are added to DSA for better corrosion resistance. In recent, 3-components or multi-components anode are studied because 2-components anode has low corrosion resistance and these electrodes show the lower overvoltage for oxygen evolution and the higher corrosion resistance.

Also, DSA needs the low overvoltage, but lifetime is very important factor. Thus, RuO_2, IrO_2, RhO_2, ZrO_2 are well used for lifetime extension, and many researches are focused on lifetime to be extended by lowering oxygen evolution potential and minimizing dissolution of oxide coatings. This work focused on the study for the influence of ZrO2 coating on the electrochemical properties and lifetime evaluation of DSA electrodes.

To make stable RuO_2, IrO_2, ZrO_2 sol at room temperature, ruthenium chloride hydrate ($RuCl_3 \cdot 3H_2O$, Kojima Chemical Co.) and iridium (Ⅲ) chloride hydrochloride hydrate ($IrCl_3 \cdot XHCl \cdot YH_2O$, Aldrich), and zirconyl nitrate ($ZrO(NO_3)_2$) are used, and isopropanol ($(CH_3)_2CHOH$, Aldrich) is used as a solvent.

Matrix for coating is used as titanium plate (gradeⅡ) and its size is 10×80×0.5 ㎜. After mechanical polishing using SiC paper #220, Ti plate is immersed for 30min. in 35% HCl solution at room temperature and rinsed. Sol-gel coating to Ti plate is performed as follows; 1 cycle coating process is dip-coating (1.0 cm/min), 1st drying (130℃, 10 min.), 2nd drying (450℃, 10 min.), and then 5 cycles are coated and finally heat treated at 450℃ for 1 hr.

Anodic polarization test (scan rate; 1 mV/sec) and cyclic polarization test(scan rate; 40 mV(SCE) are performed using a Potentiostat (Model EG&G 273A) in 25℃, 1M H_2SO_4 and 25℃, 0.5M H_2SO_4 respectively. Saturated calomel electrode is used as a reference electrode and graphite electrode is used as a counter electrode.

Lifetime is evaluated by NACE Standard TM 0294-94[9] in 3% NaCl, 4% NaOH, and simulated pore water (0.20% $Ca(OH)_2$ + 3.20% KCl + 1.00% KOH + 2.45% NaOH + 93.15% H_2O). Applied current is constantly 320 ㎃/㎠ and the experiment is continued before electrode potential reaches 4 V(SCE). Adhesion of coatings to matrix is tested by ASTM D3359-97 [10].

Figure 1 shows the effect of RuO_2 coating times on the lifetime as an insoluble anode, and Figure 2 shows the effect of ZrO_2 coating on the lifetime of RuO_2 electrode. As shown in figures, ZrO_2 coating did enhance greatly the lifetime of insoluble anode. Moreover, ZrO_2 coating improved the surface morphology and the electrochemical properties.

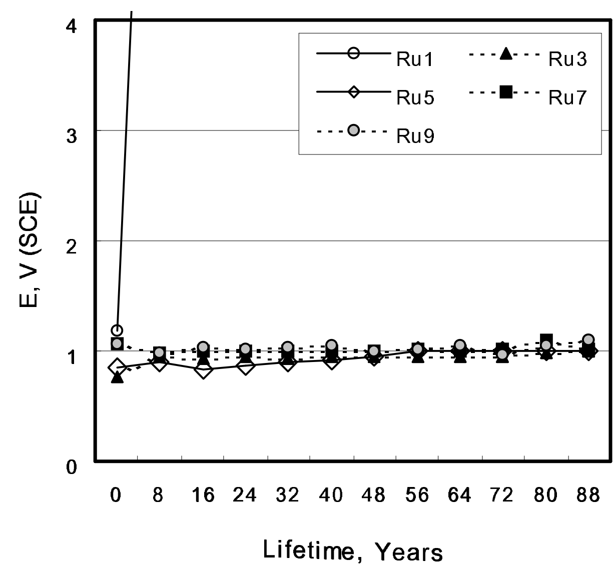

Figure 1. Effect of coating times on the lifetime of RuO_2 electrode in simulated pore water

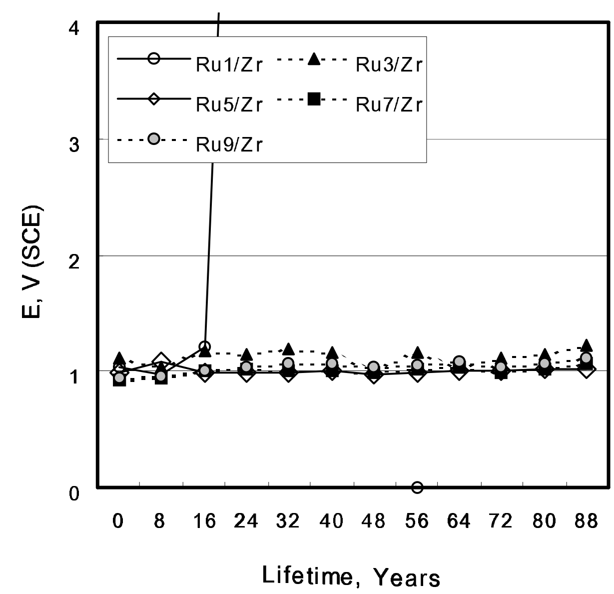

Figure 2. Effect of ZrO_2 coating on the lifetime of RuO_2 electrode in simulated pore water

References

1. Changsik Choi and Jungmin Na, *J. KSMI*, **4**, 4 (2000)
2. S. E. Hussain, A. S. Al-Gahtani and Racheeduzzafar, *J. ACI Material*, **93**, 6 (1996)
3. S. S. Kim and C. S. Choi, *J. KSMI*, **4**, 3 (2000)
4. Kangman Kim, Kyuyeun Hwang, Heechan Ko and Taewhan Yeu, *J. HWAHAK KONGHAK*, **38**, 3 (2000)
5. Kyungsun Chae, Joonhong Ahn, Hyeongki Choi and Yoseung Song, *J. Corros. Sci. Soc. of Korea*, 30, 1 (2001)
6. Kwangwook Kim, Eilhee Lee, Jungsik Kim, Jeonggil Choi, Kiha Shin, Sanghoon Lee and Kwangho Kim, *J. HWAHAK KONGHAK*, **38**, 6 (2000)
7. S. K. Yen, *J. The Electrochemical Society*, **146**, 4 (1999)
8. K. Darowicki and S. Janicki, *J. The Electrochemical Society*, **148**, 3 (2001)
9. NACE international standard test method TM0293-94, "Testing of embeddable anodes for use in cathodic

protection of atmospherically exposed steel-reinforced concrete” NACE
10. ASTM D3359-97, “Standard test methods for measuring adhesion by tape test” ASTM