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A Preliminary Study on a Piping-FAC Mitigation in a Deoxygenated Solution at pH 8.5 and 150℃ by a Platinum Dioxide Doping

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1. Introduction

In the secondary water chemistry system of the PWR nuclear power plants, a lot of the system pipes have experienced a Flow-Accelerated Corrosion (FAC). Piping FAC is generally initiated by a loss of the protective surface layer, the composition of which is mainly magnetite (Fe_3O_4), located on the inner surface of the pipes that are mostly made of carbon steels [1]. To mitigate the FAC chemically, magnetite should be protected from a severe water chemistry environment.

The previous work in this laboratory had been carried out about a pH optimization and a hydrazine concentration effect [2, 3], and we have extended our investigation to cover other type of FAC mitigation.

The purpose of the present work is to preliminarily study a platinum doping effect on piping FAC mitigation [4] under a simulated PWR secondary water chemistry condition. Though the work is still continuing, we have reached a certain conclusion.

2. Experimental

Some of the methods used to dope platinum oxide on the surface of carbon steel specimens, to identify their surface characteristics and to test the FAC weight loss are described.

2.1 Platinum dioxide oxide doping

An aqueous solution of 100 ppb-Pt and 2.43 ppm-Pt of platinum dioxide hydrated ($PtO_2 \cdot xH_2O$, Merck) were prepared with a slight ultrasonic vibration. A carbon steel specimen (commercial grade, 9.3mm x 9.0mm x 1.18mm) was placed in a vial filled with the solution. The vial was placed in a water bath at temperature of 80℃ for 18 hours.

2.2 Identification of platinum dioxide doping

The characteristics of the doped surface of the specimens were obtained by using SEM-EDX (Scanning Electron Microscope, JEOL Ltd.).

2.3 FAC testing

A FAC testing was undertaken in a deoxygenated aqueous solution re-circulated in a FAC test loop, as shown in Figure 1. The testing was done at an ammonia-controlled pH at 25℃ of 8.5 with a rotating speed of 1500 rpm at 150℃ for 62 hours.

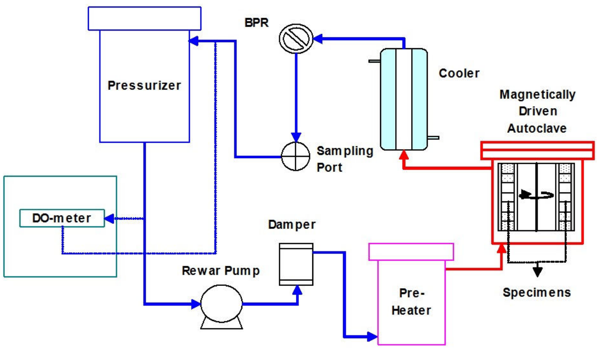

Figure 1. Schematic diagram of a FAC test loop

3. Results and Discussion

3.1 Identification of platinum dioxide doping

Figure 2 shows the surface characteristics of a carbon steel specimen doped with 2.43 ppm-Pt of platinum dioxide by using the SEM. The atomic percents of platinum measured at eleven points on the specimen are shown in Table 1.

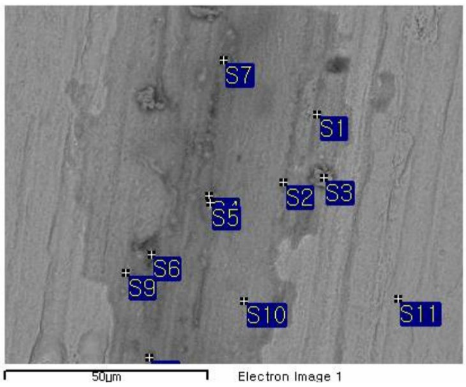

Figure 2. SEM of a specimen doped with 2.43 ppm-Pt

In Figure 2 and Table 1, it is found that six of the eleven points measured on the specimen provide evidence of a platinum dioxide doping. The atomic percents of platinum were shown to be 0.28~2.33 %. On the other hand, comparison of the doping with 100 ppb-Pt and with 2.43 ppm-Pt revealed a concentration dependency.

Table 1 EDX of a specimen doped with 2.43 ppm-Pt

Spectrum	O	Al	Fe	Pt	Total
S1	55.42	2.33	39.92	2.33	100.00
S2	50.48	3.16	45.74	0.63	100.00
S3	64.53		35.47		100.00
S4	57.19	3.78	37.74	1.29	100.00
S5	58.90	4.01	35.43	1.67	100.00
S6	57.52	1.67	40.54	0.28	100.00
S7	64.06	6.42	28.08	1.44	100.00
S8	64.94	2.15	32.91		100.00
S9	47.47	5.02	47.50		100.00
S10	42.56	2.21	55.24		100.00
S11			100.00		100.00
Max.	64.94	6.42	100.00	2.33	
Min.	42.56	1.67	28.08	0.28	
All results in Atomic Percent					

3.2 Weight loss of the specimens

Figure 3 represents the specific weight loss of six carbon steel specimens, doped with or without 2.43 ppm-Pt, in the deoxygenated aqueous solution re-circulated in the FAC test loop at an ammonia-controlled pH at 25℃ of 8.5 at 150℃ with a rotating speed of 1500 rpm for 62 hours.

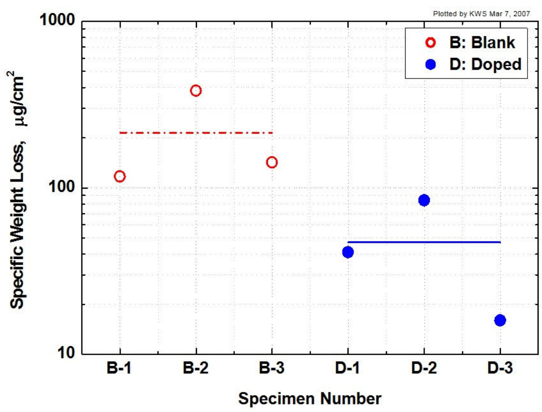

Figure 3. Specific weight loss of carbon steel specimens, doped with or without platinum dioxide, under the flow velocity of 1500 rpm for 62 hours in a deoxygenated aqueous solution at pH 8.5 and 150℃

From Figure 3, it can be seen that the three blank specimens have a specific weight loss of 117, 382 and 142 ㎍/㎠, respectively, of which the mean value is around 214 ㎍/㎠. On the other hand, the three doped specimens show 41, 84 and 16 ㎍/㎠, respectively, showing an averaged value of about 47 ㎍/㎠. In other words, it appeared that the weight loss of the carbon steel specimen due to a FAC could be decreased considerably, down to approximately a quart value, by a platinum dioxide doping.

The results support the idea that a platinum doping could be available for a piping FAC mitigation under a simulated PWR secondary water chemistry condition.

4. Conclusion

It is concluded that a piping FAC which occurs in the secondary water chemistry system of the PWR nuclear power plants could be mitigated by a platinum dioxide doping on the inner wall of the water chemistry system pipes.

Work on a measurement of the corrosion potential and polarization characteristics of carbon steel under a simulated PWR secondary water chemistry conditions is now underway for a theoretical approach. This will be discussed later in a separate paper.

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