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Development of Tubular Type Underwater Discharge Reactor to decompose Fe-EDTA from aqueous solution

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1. Introduction

In case of a nuclear industry, the wastewater is hardly generated in normal operating conditions aside from laundry rooms, particularly for wastewater contaminated by radioactive materials. However if the steam generator (SG) chemical cleaning works are carrying out, it is another story. In this case we have to predict wastewater production at least from several tons to several hundreds tons during the works. Actually Kori Unit 4 in Korea is preparing the advanced sludge conditioning agents (ASCAs) project at the next overhaul period, June-2007, to remove the tube sheet scale, and we are predicting that the 200 – 250 tons waste solutions are going to produce during this works[1].

SG chemical cleaning waste solution containing chelating agents such as EDTA is hardly easy to purify and radioactive materials included in this solution make much harder. Therefore we must have technologies to purify this chemical cleaning waste solution. The best wastewater treatment system should have great adaptability, low environmental impact, low amount of hazardous waste, and low capital and operating costs [2].

In this study we developed the underwater spark discharge system (USDS) to decompose Fe-EDTA from aqueous solution which is contaminated with radioactive materials

2. Experiment Set-Up

2.1. Tubular type underwater plasma reactor (TUPR)

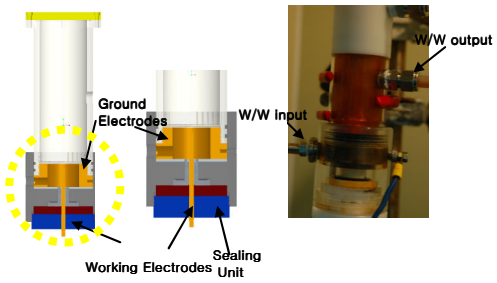

Figure 1. A design of TUPR with ring and stick electrode.

Some researcher has investigated the various plasma reactors for effectively generating a large number of radicals in water [3]. However, there was no consensus regarding the most suitable and cost effective reactor for the industrial applications.

As we make up the electrodes with stick to ring type in the TUPR, we could achieve these purposes and manage the underwater plasma reactor.

2.2. Preparation of test sample.

The compositions of test sample are as shown in Table 1. Especially an analysis of EDTA concentration was titrated by $ZrOCl_2$ [1].

Table 1. Composition and analysis of test sample

Items	Concentration	Analysis
TOC (Total Organic Carbon)	13,357mg/L	Shimadzu, Japan Model: TOC-V
TN(Total Nitrogen)	4,875mg/L	
EDTA	0.15mol/L	Titration Method
Conductivity	16.9mS/cm	Thermo, USA Model: 250+
pH	9	

2.3. Preparation of experimental apparatus

This new AC underwater electric discharge system is characterized by submerging electrodes in the solution, producing and maintaining a high intensity electric arc between a working electrode and a ground electrode [4].

The USDS consists of the following main 5 parts: (1) a Fenton Reactor, (2) a TUPR, (3) a Buffer Tank (B/T), (4) a Heat Exchanger, and (5) a Power Supply system. The flow diagram of USDS is shown in Fig. 2.

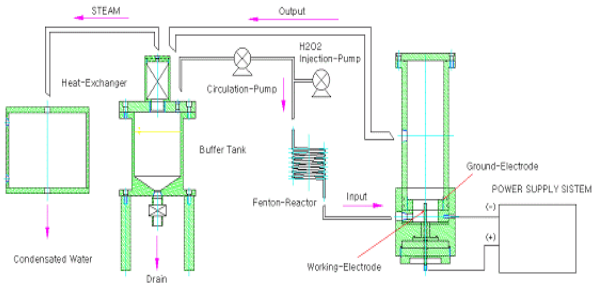

Figure 2. Schematic diagram of the underwater spark discharge system

A total volume of 1 L of test sample containing 0.15 mol/L Fe-EDTA was circulated through the TUPR

by peristaltic pump at a flow rate of 340 mL/min. H_2O_2 (Purity 35%) was used 25 v/v% of the volume of initial test sample. At steady state the current was approximately 1 – 2 A, the voltage was 540V, and the frequency was 250 Hz. In this system purified water was able to get from condensate water finally, which was cooled steam produced in B/T.

3. Experiment Results

The experiment results were summarized in Table 2 and Figure 3 was shown the trends of organic waste concentration according to the reaction time. After 90 minutes of reaction time, the degradation efficiencies of TOC, and EDTA were 67.2% and 96.2%. The production of condensate water was about 8.4mL/min.

Table 2. Summary of experiment results using USDS

RXN Time (min)	TOC (ppm)	EDTA (mol/L)	TN (ppm)	W/W vol. in B/T (mL)	H_2O_2 feeding vol. (mL)	Evaporation rate of W/W in B/T (mL)	Conductivity (mS/cm)
0	13357	0.1486	4875	1000	0	0	16.9
10	13562	0.1548	5897	966	41.3	75	16.5
20	13895	0.1530	6890	923	41.3	85	19.2
30	14317	0.1607	4398	873	41.3	91	20.7
40	13876	0.1409	3854	836	41.3	78	19.7
50	12478	0.1297	3674	780	41.3	98	22.4
60	10954	0.0981	3459	731	41.3	90	26.5
70	8760	0.0478	3319	689	41.3	83	28.4
80	5342	0.0184	3216	652	41.3	78	30.7
90	4378	0.0050	3198	618	41.3	76	32.6

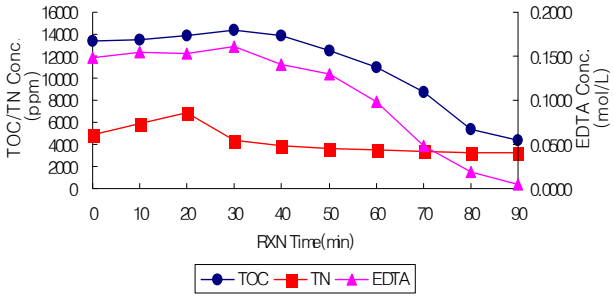

Figure 3. Variations of TOC, TN, and EDTA concentration according to the reaction time.

Water quality of cooled steam resulting from the B/T was analyzed according to reaction time. As shown in Figure 4, concentration of TOC was about 130 ppm and TN was 400 ppm. As a result of analysis, we knew the TOC and TN were induced by amine compounds such as R-NH, or R-NH-R. Therefore, we need to install a purifying system to discharge the cooled steam safely to environment.

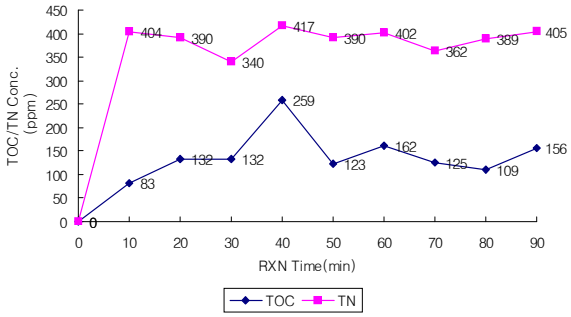

Figure 4. Changes of TOC and TN concentration of cooled steam produced in the B/T

4. Conclusions

The underwater spark discharge system (USDS) was developed to decompose Fe-EDTA from aqueous solution which was contaminated with radioactive materials. Especially this system is not to decompose all kinds of organic materials but to degrade EDTA into low level organic compounds. After 90 minutes of reaction time, the degradation efficiencies of TOC, and EDTA were 67.2% and 96.2%. Then, the production of condensate water was about 8.4mL/min and its TOC and TN concentration was about 130 ppm and 400 ppm. These kinds of contaminants were induced by amine compounds such as R-NH, or R-NH-R, which were produced during EDTA decomposition.

In the future works, we are plan to install the catalyst reactors to purify the cooled steam.

5. References

1. Jin-Kil Kim and Duck-Won Kang, *Thermal plasma treatment of EDTA-Based Steam Generator Chemical Cleaning Waste Solutions in a Kori NPP*, EPRI 2007 LLW Conference & Exhibit show, *Accepted on Feb-2007.*

2. Radu Burlica, Michael J. Kirkpatrick, Wright C. Finney et al, *Organic dye removal from aqueous solution by glidarc discharge*, J. of Electrostatics 62(2004) 309 – 321.

3. Jin-Kil Kim and Duck-Won Kang, *Electric Discharge System for treating EDTA-Based Steam Generator Chemical Cleaning Waste Solutions in NPPs*, EPRI 2006 LLW Conference & Exhibit show, 2006(Summer).

4. Istvan Shremmer, *Electrical discharge processes for the treatment of liquid phase hazardous waste, physical and chemical aspects (Unpublished an Article)*, G.I.C. Ltd. 2005.