Transactions of the Korean Nuclear Society Spring Meeting
Chuncheon, Korea, May 25-26 2006

Treatment of TBP/Dodecane by utilizing DU Oxidation Apparatus and Furnace

Kil Jeong. Kim, Il Sik, Kang, Jong Sik, Shon, and Kwon Pyo, Hong
Division of Nuclear Fuel Cycle Examination Facility, Korea Atomic Energy Research Institute

1. Introduction

Various kinds of organic radioactive liquid wastes are generated from nuclear fuel cycles and the related research laboratories. A strategy for the effective treatment is needed, because organic radioactive wastes require both aspects for their activities and chemical contents, which have detrimental effects on health and the environment.

Several techniques for conditioning organic radioactive wastes have been developed.[1-2] Incineration and wet oxidation are attractive techniques, but the combustion produces corrosive products, and wet oxidation also generates an undesirable secondary waste solution. A simple evaporation technique was adopted in the previous study for major organic wastes, such as acetone, alcohol, TBP/Dodecane, and cutting oil by utilizing established oxidation apparatus and ventilation system.[3]

In this study, the utilization of furnace as a heating device is studied, and effects of the temperature and amount of solvents on an evaporation time are described.

2. Experimental Methods

2.1 Reagents

- Chemicals : Extra pure grade of solvents, such as TBP, and dodecane, are used
- Apparatus : A typical type of a small muffle furnace is utilized as a heating device and a little modified for the direct removal of the generated vapors before condensation.

3. Results

3.1 Characteristics of Organic Radioactive Wastes

The composition of tributyl phosphate(TBP) and dodecane wastes is presented in Table 1. TBP and dodecane wastes show fairly high uranium concentrations, while the activity are rather low.

Table 1 Major Composition and Radioactivity in TBP/Dodecane Waste Solution

Solvents	Content %	Nuclides	U Concn. μg/ml	Gross-α Bq/ml
TBP Dodecane	30 70	U/Th/ Pu/Am	3,300	9.67

3.2 *Evaluation of the Evaporation Time depending on different Amount of each Solvent*

Evaporation temperature is adapted by considering the boiling point of an objective solvent. Results from the evaporation on acetone, alcohol, and cutting oil as organic wastes are reported in the previous paper[3] by utilizing DU oxidation apparatus and ventilation system. For solvents having low boiling point like acetone and alcohol, there were not much differences in the evaporation time with increasing temperatures and amounts of solvents, and the whole evaporation were completed within 2 to 3 hours for 8 L of solvents. While, an evaporation for the mixture of TBP and dodecane was very slow, and the whole evaporation took above 14 hours for 8 L of the mixture(Fig. 1),which is considered to be due to the high b.p. of 289 °C for TBP and 216 °C for dodecane. Furthermore, the heating temperature should be limited below 200 °C to exclude any possible spontaneous ignition of the vapor by contacting with air at above 200 °C.

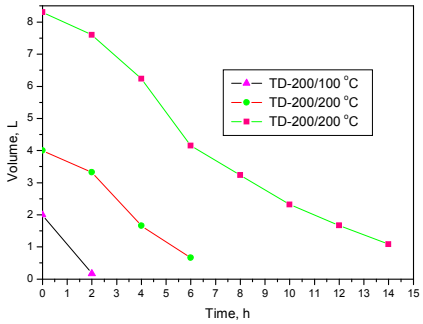

Fig. 1 Evaporation Time for TBP/Dodecane with different Amounts and Temperatures

3.3 *Application of Furnace for the Evaporation of TBP/Dodecane*

A general muffle furnace is adopted as a heating device for the evaporation of TBP/Dodecane with the high boiling point, in order to give the effective heating within a short time and to evaporate solvent at the rate of relatively small amount. Especially for the removal of generated vapors, aspirating system by water is connected with the furnace. By these modification, the solvent can be treated without any condensation of vapors and an unexpected ignition caused by contacting with air.

3.3.1 Modification of furnace

Two discharging lines are established into furnace and connected to each aspirating system to directly remove generated vapors. A small sus-frame and five trays are placed inside the furnace as shown in Fig. 2. The dimensions of inside the furnace is

W120xH90xD250 mm, and the total capacity per one batch is 0.5 L with 5 trays having each dimension of W90xH10x200 mm.

Fig. 2 Establishment of the discharging Lines for Vapors and sus-Frame with Trays

3.3.2 Evaporation time for TBP/Dodecane with different temperatures and amount.

Evaporation times for TBP/Dodecane depending on the amount of the solvent at different temperatures were experimented and summarized in Table 2.

100 ml of the solvent using one tray is evaporated within one hour at 130 °C and 140 °C, while, at above 150 °C, evaporation times were reduced to 30 minutes with increasing heating temperatures. In the case of 200 ml and 300 ml of the solvent, those were vaporized within one hour at below 200 °C and 30 minutes at above 300 °C. It is understood that evaporation is not much affected with the increasing amount of the solvent by utilizing furnace. The full capacity of furnace, 500 ml was completely evaporated within one hour at 200 °C.

It should be noted that evaporation condition should be optimized between the amount of the solvent and the heating temperature, because the vapor is quite inflammable by contacting with fresh air, when the vapor become dense by using a large amount of the solvent and heating at above 250 °C.

Table 2 Evaporation Time for TBP/Dodecane using Furnace with the increasing Temperatures

Solvent (ml)		Evaporation Time (min)					
		130 ℃	140 ℃	150 ℃	200 ℃	300 ℃	400 ℃
TBP + Dode -cane	100	60	60	35	40	30	25
	200	60	60	60	60	30	30
	300	120	60	-	60	30	30
	400	-	-	-	60	-	-
	500	-	-	-	60	-	-

The maximum evaporation capacity is evaluated to 3 L for one batch and at least 10 L per a day by a low-price commercial muffle furnace having the dimension of W160xH250xD300 mm.

3.3.3 Estimation of the radioactivity in the discharging water

The concentration on uranium isotopes in effluents should satisfy the minimum concentration of 10 Bq/g for each U isotopes, which is regulated by the national authority. The uranium concentration in the mixed water with organic vapors is calculated by considering the uranium concentration in the waste, 9.6 Bq/ml, the amount of wastes to be treated, and water to be discharged at an unit time.

The concentration of uranium was evaluated into 3.4 Bq/g in the discharging water, as shown in Table 3, which corresponds to be one third minimum requirement, and, with an additional discharging line and pressure pump, maximum treatment capacity by using furnace is extended to 2 L per an hour below the regulatory limit.

Table 3 Estimation of U Concentration in the discharging Water

Exempn. Level Bq/L	Waste Concn. Bq/L	Treatmt. Capacity L/H	Water Discharge L/H	Dilutn. Ratio	Final Concn. Bq/L
10	10,000	0.5	1,500	3,000	3.4
		2.0	2,500	1,250	8.0

4. Conclusion

It is concluded from the results that a typical muffle furnace is effectively applicable finally to dispose of those organic wastes having a higher boiling point like TBP/Dodecane within a relatively short time and without any condensation of vapors by an aspirating system.

REFERENCES

[1] Dirks, F., Hempelmann, W., “The Incineration Plant of the Karlsruhe Nuc. Resea. Cent.”, Incineration of Radioactive Waste(Proc. CEC Sem. Arnhem, 1984), Rep. CEC-EUR-9621, Graham and Trotman, London, 34-47(1985).

[2] Wilks, J.P., Holt, N.S., Wet Oxidation of Mixed Organic and Inorganic Radioactive Sludge Wastes from a Water Reactor, Waste Management 10, 197-203(1990).

[3] Kil J. Kim, Il S. Kang, Jong S. Shon, Kwon P. Hong, Treatment of Organic Radioactive Wastes by Evaporation Process utilizing DU Oxidation Apparatus, Transaction of the Korean Nuclear Society Autumn Meeting, Busan, Korea(2005) .