APPLICATION OF HIGH TECHNOLOGY POLYMERS FOR THE IMMOBILIZATION AND SOLIDIFICATION OF COMPLEX LIQUID RADWASTE TYPES

Dennis Kelley (**Pacific World Trade, Inc., Indianapolis, IN, USA**), Ward Brunkow (**The Chamberlain Group, Lynchburg, VA, USA**)

Yuri Pokhitonov, Vadim Starchenko (**V.G. Khlopin Radium Institute, St. Petersburg, Russia**)

ABSTRACT

The Cold War era created a massive build-up of nuclear weapon stockpiles in the former Soviet Union and the United States. The primary objective during this period was the development of nuclear technologies for weapons, space and power with lack of attention to the impact of radioactive and hazardous waste products on the environment. Effective technologies for radioactive and hazardous waste treatment and disposal were not well investigated or promoted during the arms build-up; and consequently, environmental contamination has become a major problem. These problems in Russia and the United States are well documented.

Significant amounts of liquid radwaste have existed since the 1950's. The current government of the Russian Federation is addressing the issues of land remediation and permanent storage of radwaste resulting from internal and external pressures for safe cleanup and storage. The Russian government seeks new technologies from internal sources and from the West that will provide high performance, long term stability, safe for transport and for long-term storage of liquid radwaste at a reasonable economic cost.

With the great diversity of liquid chemical compositions and activity levels, it is important to note that these waste products cannot be processed with commonly used methods.

Different techniques and materials can be used for this problem resolution including the use of polymer materials that are capable of forming chemically stable, solidified waste products.

In 2001, the V.G. Khlopin Radium Institute (St. Petersburg, Russia) and Pacific World Trade (Indianapolis, Indiana) began an extensive research and test program to

determine the effectiveness and performance of high technology polymers for the immobilization and solidification of complex liquid radwaste types generated by the Ministry of Atomic Energy (Minatom), Russia, organization. The high tech polymers used in the tests were provided by Nochar, Inc. (Indianapolis, Indiana).

INTRODUCTION

More than 99% of fissionable products and transuranium elements generated by nuclear plant operations are associated with spent nuclear fuel (SNF). Spent fuel is the source for most of the harmful radionuclides. Other than SNF, large inventories of mixed liquid composition radioactive products are accumulated at radiochemical and nuclear production plants that result in serious long-term threats to the environment. (1,2). Among these products are aqueous solutions of different specific activity levels and various compositions of organic and aqueous-organic combinations, including spent extractants and hydrocarbon diluents. Due to the the significant diversity of the chemical compositions and activity levels, these liquid waste products cannot be treated effectively by using common methods, be it a universally accepted one.

Therefore, one way to improve waste management standards and increase the safe handling of such radwaste is to develop a technology that will treat various chemical compositions by the creation of a solid form as the final product. The solid form will reduce the risks to human life, protect the environment and present a safe solution for disposal.

The solidification of liquid radwaste provides safety for transportation of materials and, in the case of emergencies, solidification of solutions directly into the closed vessels or tanks will prevent the spread of contaminated liquids into the environment. Different techniques and products may be applied to the complex problems including the use of high technology polymers which are capable of rapid solidification without leaching, by raising the flashpoint of the total waste and forming a stable mass containing radionuclides.

The goal is to seek effective, high performance technologies that can meet these requirements while meeting overall economic and cost objectives.

NOCHAR TECHNOLOGY DESCRIPTION

High tech polymers have been developed by Nochar, Inc., Indianapolis, Indiana, for the solidification of liquid radwaste types such as organics, hydrocarbons, tritiated oils, aqueous solutions, acids and various sludges that may include heavy metals. Nochar products have been applied to waste streams at U.S. Department of Energy sites: Mound, Ohio; Rocky Flats, Colorado; Los Alamos and Sandia labs, New Mexico; Hanford, Washington; and Savannah River, South Carolina. Also, Nochar has been used by Atomic Energy Canada-Whiteshell. Projects at these sites include the solidification of LLW and HLW. (3-4)

Nochar's polymers are non-toxic, non-hazardous with fire retardant properties. Primary advantages are no leaching / leaking and minimal volumetric increase. The polymers solidify liquids by means of a molecular and mechanical process. Solidification results in various final forms depending on the chemical composition of each radwaste type. With radioactive and metal content, the solidification ratio can vary from 1:1 to 8:1 (liquid by weight to Nochar polymer).

Figure 1. Polymer Added to Nitric Solution at Gatchina, Russia

PROGRAM OBJECTIVES

Testing and research efforts have been ongoing at Minatom sites in Russia since 2001 and will continue into 2003. The primary objective of the investigation is to validate the use of the polymers to solidify and immobilize actual liquid radwaste types as produced by the radiochemical plants during the past decades. This paper examines the results of the testing and research work to date.

RESULTS OF THE EXPERIMENTS

Testing on actual aqueous and organic radioactive waste has been conducted at Gatchina (Khlopin R.I.) and at "RADON" (Sosnovy Bor), northern Russia. The following groups of waste have been selected for the solidification tests:

- Sludge residues resulting from the evaporation of various complex decontaminating solutions
- Several process products generated from the extraction facility operation for spent fuel processing (Purex process)
- Solutions of various compositions including sludges furnished by RADON

- Spent extractant solutions of many compositions

More than fifty (50) experiments have been performed and investigated. Selected results of the solidification tests are shown in Tables 1-4.

A. Experiments on Solidification of Sludge Residues Resulting from the Evaporation of Decontaminating Solutions

Test No.	Characteristic Composition of Waste	Solidification Conditions Volume ml	Solidification Conditions Polymer N960 / N910 grams	Results
4237	LL Decontaminating Solution with Low Organic Substances Cs 137 + 134, 10^5 bq/l	12	8 / 2	Solidified to rubbery state Waste stabilized well
4238	LL Decontaminating Solution with Low Organic Substances U-153 g/l, $NaNO_3$, HNO_3	13-15	4 / 1	Solidified to rubbery state. No free liquids. Waste stabilized well, Compaction with tool.
4232	Sludge residue from bottom of tank (aqueous phase) U-80g., $NaNO_3$, HNO_3	6	8 / 0.5	Solidified No free liquids
4231	Sludge residue from top layer of tank (organic phase) Very thick black sludge	15	16 / 0.5	Solidified No free liquids
4125	Precipitate in the sample HNO_3, U-20 g, $NaNO_3$	15	16 / 0.5	Solidified

B. Experiments on Solidification of Products Generated during the Operation of the Extraction Facility

4283	Uranium Extractant	Combination of Polymers	Solidified, Sample used for Leach Test
7201	Plutonium Extractant		Solidified
6509	Cesium Extractant		Solidified

7219	Neptunium Extractant		Solidified
7218	Extractant Saturated with Neptunium		Solidified

C. Experiments on Solidification of Solutions / Liquids of Complex Compositions Originating from RADON

001	Sludge containing various solutions in stratified condition	Combination of Polymers	Solidified rapidly; No free liquid; Passed filter leach test.
002	Various Solutions from underground tanks		Solidified; No free liquid; Passed filter leach test
003	Sludge residue		Solidified, Passed filter leach test

D. Experiments on Solidification of Spent Extractants of Various Chemical Composition

	Waste Composition	Volume ml	Polymers grams N960	Polymers grams N910	Polymers grams N930	Results
01	0,27 Mole / 1 CCD+6% OP-10 in F3	6.5	2	8		Solidified, no leaching
02	0,075 Mole / 1 CCD+0,025 Mole / 1 diphenyl-N, N-dibutyl-carbamoylphosphine oxide (CMPO = 0.5% PEG-400 in FS-13)	6.5			6	Slow solidification; New Polymer formula
03	0,075 Mole / 1 CCD + 0,025 Mole / 1 CMPO + 0.5% PEG-400 in FS-13	6.5	2	6		Solidified, no leaching

Figure 2. Extractant Solution

Figure 3. Polymer Solidification

CONCLUSION

As a result of the test program, we can conclude that the high tech polymers can, in fact, solidify radwaste products that vary in composition and in specific activity. Further work has to be performed to determine exact bonding ratios (weight ratio of the radwaste liquid to the polymer formula) per waste stream for efficiency and economic considerations.

The use of the polymers may have multiple applications in the area of radwaste treatment and disposal as well as for processing highly toxic chemical waste. The polymers will also have applications at NPPs in case of emergency spills.

The unique aspect of the new technology will allow complex liquid radwaste products to be solidified into a stable, no leachable waste product that can be suitable for long-term storage and final disposal. One possibility for final disposal is "wet" incineration at high temperatures. The polymers meet all U.S. EPA standards for incineration. Incineration will result in substantial volume reduction of the waste. Remaining residues from incineration could be incorporated into a ceramic matrix.

We are encouraged by the results of the test program and believe that there is a role for the use of polymers in northern Russia and Siberia, as well as in the international nuclear waste industry.

REFERENCES

1. "Behind the Nuclear Curtain: Radioactive Waste Management in the Former Soviet Union", by Don J. Bradley. Edited by David R. Payson 1997

2. "Radioactive Waste Management in the Russian Federation", by Egorov, N.N.; Akhunov V.D.; Parker F.L.; Willey L.J.; Radioactive Waste Management and Environmental Restoration: A Multinational Journal, 1997. Harvard Academic Publishers, Washington, D.C.

3. "Nochar Petrobond Absorbent Polymer Tritiated Oil Solidification", Innovative Technology Summary Report, DOE / EM-0598. September, 2001

4. "Solidification of (HB-40) Reactor Coolant Organic Waste with Nochar Petrobond", by Ward Brunkow. Site: AECL Whiteshell Labs, Pinawa, Manitoba, Canada. June, 2002