Nitrate to Ammonia Ceramic (NAC) Bench Scale Stabilization Study

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Introduction

Department of Energy (DOE) sites such as the Hanford site, Idaho National Engineering Laboratory (INEL), Savannah River site, Oak Ridge National Laboratory (ORNL) have large quantities of sodium-nitrate based liquid wastes. At INEL alone there are 800,000 gallons. The largest quantity of these wastes is the 149 single shell tanks (SSTs) tanks at Hanford which can hold 1 million gallons each.

Problem

Stabilization of this waste is difficult because nitrates are very mobile. Additionally vitrification of these wastes produces large quantities of hard to manage NOx emissions.

A process called the Nitrate to Ammonia Ceramic (NAC) has been developed at ORNL, by A.J. Mattus, to remove a majority of the nitrate content from wastes such as these. In the NAC process solid aluminum at low temperatures (50-80°C) and low energy, reduces nitrate to ammonia, and a solid aluminum oxide material is formed. The process destroys the nitrates.

In the initial development of the NAC process the aluminum reduces the nitrates to ammonia. A raw product is formed which is then calcined at 600-800°C. This product is then uniaxially pressed at 10,000 psi and sintered in the range of 1300-1400°C to form a ceramic like product.

To take the raw product to the ceramic stage requires significant energy to heat the waste to a high temperature. At these high temperatures, volatile radionuclides may be released, creating additional containment problems. In addition a large scale ceramic process capable of handling the large quantity of raw product is currently not available.

Solution

Because of these concerns and issues, alternative ways to form a solid non-leachable product are desired. As detailed below, RUST-Clemson Technical Center, is investigating other stabilization options for the raw sludge produced from the NAC process. Results will indicate which of the stabilization hosts can be used to stabilize the raw NAC material.

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Technology Description

The NAC solid product will be produced using a nitrate solution spiked with 8 RCRA metals (As, Ba, Cd, Cr, Pb, Hg, Se, & Ag) and 3 semi-volatile organics (2,4-Dinitrotoluene, 2,4,6-Trichlorophenol, and Nitrobenzene). Rather than taking this product to the ceramic stage, four low temperature stabilization hosts will be examined. Each of the stabilization hosts selected have been previously considered and/or used for stabilization of radioactive and/or hazardous wastes.

The process layout for this treatability study is shown in Figure 1. A waste product (NAC sludge) was produced by adding powdered aluminum into the RCRA contaminated nitrate solution. Reaction temperature was maintained at 50-80°C. The raw product produced was filtered and then dried to a powdery consistency. This raw product will be stabilized as detailed in the following paragraphs.

A waste loading of 55-75% will be investigated for portland cement/flyash stabilization. This well established stabilization technology chemically fixates RCRA constituents.

The second stabilization host, sulfur polymer cement (SPC) is an encapsulation process. The waste loading to be investigated will be 35-90%.

Vinyl ester styrene is also an encapsulation process. Waste loadings for this host will be 35-90%.

The fourth stabilization host is high alumina cement. Ca(OH)₂ will be combined with the NAC slurry (which is high in alumina) at approximately 70% waste loading, to create a stabilized waste form. If problems occur with flash set, a retarder may be utilized. Other options may have to be pursued to overcome flash set problems.

Initial screening tests will be conducted to determine the waste loadings for each stabilization host. Screening formulations will be evaluated based on visual observations of mixing ability, 24 hour load bearing strength and evaluation of stabilization performance using a quick leach with leachate screened for RCRA constituents.

Once the waste loadings have been determined, performance comparisons for each stabilization host will be based on leachability and compressive strength. Each waste form will be subjected to a TCLP analysis of 8 RCRA metals and three semi-volatile organics. Leachability of sodium from the stabilized products will be tested by ANSI 16.1 method (abbreviated test). The unconfined compressive strength will also be determined for each host.

Application

The NAC process can utilize the large existing inventory of scrap aluminum at DOE facilities. Some of this aluminum has been irradiated and the NAC process offers an economical disposal option for this waste. This process can be used to treat the large amount of tank wastes at DOE facilities.

Utilizing the NAC process, a problematic waste stream constituent (sodium nitrate) can be decomposed to an innocuous gas (ammonia). The residual product can then be incorporated into a stabilized waste form for disposal.

Future Activities

The treatability study utilizing the four stabilization hosts is currently being conducted. Further studies in this area may be warranted.
Acknowledgements

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Figure 1: NAC SCREENING TESTS

- NAC WASTE
  - PORTLAND CEMENT 55, 65, 75%
  - FURNACE CEMENT 70%
  - SULFUR CEMENT 30, 50, 70%
  - VINYL ESTER STYRENE 50, 70, 90%

Percentages are percent waste loadings

- MIXING EFFICIENCY
- STRENGTH TEST
- QUICK LEACH

WASTE LOADINGS