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Mixed Waste Treatment Using the ChemChar Thermolytic Detoxification Technique¹

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Introduction and Need

The diversity of mixed waste matrices contained at Department of Energy sites that require treatment preclude a single, universal treatment technology capable of handling sludges, solids, heterogeneous debris, aqueous and organic liquids and soils. Versatility of the treatment technology, volume reduction and containment of the radioactive component of the mixed waste streams are three criteria to be considered when evaluating potential treatment technologies. Thermal technologies typically offer waste stream versatility and volume reduction, but suffer from potential volatilization of contaminants, most importantly radioactive species, and thus require extensive off-gas treatment trains. The need for a treatment system that can accept a wide variety of waste matrices, achieve regulatory destruction efficiencies for contaminants and produce a clean effluent is highly desirable.

Approach

The ChemChar thermolytic detoxification process being developed under this R&D contract is a thermal, chemically reductive technology that converts the organic portion of a mixed waste stream to an energy-rich

synthesis gas while simultaneously absorbing volatile inorganic species (metals and acid gases) on a macroporous, carbon-based char. The latter is mixed with the waste stream prior to entering the reactor. Substoichiometric amounts of oxidant are fed into the top portion of the cylindrical reactor generating a thin, radial thermochemical reaction zone. This zone generates all the necessary heat to promote the highly endothermic reduction of the organic components in the waste in the lower portion of the reactor, producing, principally, hydrogen and carbon monoxide. The solid by-product is a regenerated carbon char that, depending on the inorganic loading, is capable for reuse. The in situ scrubbing of contaminants by the char within the reactor coupled with a char filter for final polishing produce an exceptionally clean synthesis gas effluent suitable for on-site generation of heat, steam or electricity. Despite the elevated temperatures in the thermochemical reaction zone, the reductive nature of the process precludes formation of nitrogen oxides and halogenated organic compound by-products.

Project and Technology Description

The principle objective of this Research Opportunity Announcement program will be to treat two surrogate mixed waste streams in a four inch diameter, continuous feed, adiabatic reactor (Figure 1) to regulatory treatment levels for the organic contaminants and simultaneously absorbing the radioactive surrogate

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species on the char. Extensive sampling of the gaseous effluent will be performed throughout the duration of process runs to ensure destruction of organic contaminants and absorption of inorganic species.

The surrogate mixed wastes to be tested under the program include an aqueous based surrogate containing four soluble Resource Conservation and Recovery Act (RCRA) metals, two radioactive surrogate metals and several RCRA organic compounds (chlorinated and non-chlorinated, see Table 1). The second surrogate mixed waste to be tested is an organic sludge with the same RCRA and surrogate radioactive components as the aqueous waste (see Table 2). The anticipated ten month program has two main project tasks: (i) design and construct a four inch, adiabatic, continuous feed ChemChar reactor at Mirage Systems in Sunnyvale, California; (ii) treatment of the mixed waste surrogates at the University of Missouri, Columbia campus.

Accomplishments

The ChemChar waste treatment process has been tested on the bench scale in two inch diameter, non-adiabatic, batch reactors on a variety wastes at the University of Missouri over the past eight years. These successful, bench-top treatability studies have proven the principle reductive attributes of the process for the conversion of waste materials to a valuable, energy rich, synthesis gas. numerous wastes matrices and contaminants were treated by the ChemChar process including soils, organic tars and sludges, still bottoms, and radioactive metal containing ion exchange resins. Specific contaminants included PCBs, chlorinated benzenes, and volatile RCRA

metals. The outcome of these studies consistently resulted in >99.99% destruction and removal efficiency for the organic components and gaseous effluents free of acid gases (hydrochloric acid and nitrogen oxides) and volatile metals (cadmium, mercury, lead). The current program will focus on system optimization and heat management for a four inch diameter reactor for accumulation of data to be used for construction of a pilot system.

Application/Benefits & Future Activities

Successful completion of this program will result in a versatile mixed waste treatment technology ready for pilot plant scale-up. The principle benefit will be the eventual commercialization of a mixed waste treatment system capable of handling a significant volume of the current inventory of wastes across the DOE complex. This recently initiated program will focus initially on the design and construction of a continuous feed, computer controlled ChemChar system, followed by transport of the reactor to the University of Missouri for mixed waste surrogate testing. Pilot scale design and construction is planned for mid-1996.

Acknowledgment

Support for this contract has been provided through Mr. Richard Dennis (the project COR) and METC. The period of performance for this program is 6/95-4/96. The research to be performed at the University of Missouri is headed by Dr. David Larsen (St. Louis) and Dr. Stanley Manahan (Columbia). This program is under the Mixed Waste Focus Area of EM.

Figure 1. Schematic diagram of the continuous feed ChemChar reactor to be constructed under this program.

Table 1
Composition of the High Organic
Sludge Surrogate Mixed Waste

No.	Component Name	Wt %
1	Activated carbon	10
2	Water	20
3	Perlite	10
4	Fe ₂ O ₃	10
5	CaSO ₄ *2H ₂ O	10
6	Al ₂ O ₃	5
7	Ethylene glycol	14.5
8	Mineral Oil	12
	Total	91.5

RCRA Metals

9	CrCl ₃ *6H ₂ O	0.25
10	NiCl ₂ *6H ₂ O	0.25
11	PbCl ₂	0.25
12	CdCl ₂ *2.5H ₂ O	0.25
	Total	1

RCRA Organics

13	Naphthalene	3
14	1,2-Dichlorobenzene	2
15	Chlorobenzene	2
	Total	7

Radionuclide Surrogates

16	CeCl ₃	0.25
17	CsCl	0.25
	Total	0.5

Table 2
Composition of the Aqueous
Surrogate Mixed Waste

No.	Component Name	Wt %
1	Activated Carbon	10
2	Water	75
3	CaCl ₂	3
4	NaHCO ₃	3
5	MgSO ₄ *7H ₂ O	3
6	Na ₂ HPO ₄ *7H ₂ O	2.5
7	Fly ash (ASTM F)	1
	Total	97.5

RCRA Metals

8	Cr(NO ₃) ₃ *9H ₂ O	0.25
9	Ni(NO ₃) ₂ *6H ₂ O	0.25
10	Pb(NO ₃) ₂	0.25
11	Cd(NO ₃) ₂ *4H ₂ O	0.25
	Total	1

RCRA Organics

12	Naphthalene	0.4
13	1,2-Dichlorobenzene	0.3
14	Chlorobenzene	0.3
	Total	1

Radionuclide Surrogate

15	CeCl ₃	0.25
16	CsCl	0.25
	Total	0.5