

Treatment of Mixed Waste via Fixed Bed Gasifier

Stanley E. Manahan (chemstan@showme.missouri.edu, 573-882-6429)

Scott Martin (c700947@showme.missouri.edu, 573-882-5422)

Kenneth Garrison (c699379@showme.missouri.edu, 573-882-5422)

ChemChar Research, Inc./University of Missouri

Department of Chemistry

123 Chemistry Building

University of Missouri

Columbia, MO 65211

J. Steven Morris (morris@reactor.murr.missouri.edu, 573-882-5265)

James Colbert

University of Missouri Research Reactor

Columbia, MO 65211

David W. Larsen (larsen@jinx.umsl.edu, 314-516-5341)

Department of Chemistry

University of Missouri-St. Louis

8001 Natural Bridge Road

St. Louis, MO 63121

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Abstract

Gasification, a thermal process in which carbonaceous solids and/or liquids are reacted with a substoichiometric amount of oxidant or with a reductant to produce combustible gases or vapors, can be used to treat a number of hazardous wastes, and is especially effective in destroying organohalide compounds, such as chlorobenzene. Unlike incineration, gasification produces a combustible reduced gas product that does not contain oxidized contaminants, such as SO_x or NO_x. Because the volume of gas produced by gasification is only about one third that produced by incineration, much less gas requires treatment. Particularly important for the gasification of organohalides is the fact that gasification does not generate chlorinated dibenzodioxins and dibenzofurans, which can cause problems in the incineration of organochlorine compounds. Surprisingly, given its inherent advantages for waste treatment and the huge technology base derived from more than 150 years of experience in coal conversion, gasification has received comparatively little attention in the U.S. as an option for treating hazardous wastes.

ChemChar gasification¹ discussed in this paper is a cocurrent flow process meaning that the wastes and solids, the reactant gases, and the product gases all flow the same way through the reactor when it is operated in a continuous-feed mode. This is the optimum configuration for waste destruction because all wastes are forced to pass through the thermal gasification zone before exiting the reactor and are thus subjected to high-temperature reductive destruction conditions.

The ChemChar process has been studied extensively for the destruction of a variety of

wastes.² In addition to mixed wastes containing organic substances and radioactive materials, other wastes that have been studied are refractory organic waste sludges including those containing both PCBs and heavy metals, sewage sludge, spent activated carbon, and contaminated soils.

A key to the efficacy of ChemChar waste treatment is that for most applications gasification is carried out on a matrix of macroporous char to which the wastes have been sorbed. The char is produced from subsequent gasifications of subbituminous coal (Hanna, Wyoming) in a batch reactor in which oxygen is passed upward through a cylindrical container filled with granular coal or char, and a thermal zone, or "flame front," initiated at the top of the cylinder passes counter to the flow of oxygen. This "reverse-burn" process is repeated three times to produce a "triple-reverse-burn" (TRB) char which has many beneficial properties including (1) it is highly macroporous with a surface area of around 200 m²/g; (2) it is inexpensive to produce; (3) it sorbs a wide variety of wastes, both organic and inorganic; (4) it is an ideal matrix for mixing, drying and retention of sludges; (5) the carbonaceous surface of char provides a matrix on which thermochemical reactions can occur under controlled conditions; and (6) char provides an excellent starting material from which immobilized heavy metals or radionuclides can be processed to provide a non-leachable final disposal form.

A 4-inch diameter, continuous-feed ChemChar pilot scale reactor was constructed and operated and tested on surrogate mixed wastes containing hazardous organic and inorganic constituents and non-radioactive surrogates for radionuclides. Waste constituents included chlorobenzenes, naphthalene, mineral oil, nonradioactive cesium and strontium, cerium (surrogate for plutonium), selected heavy metals, and other organic and inorganic species. The destruction/removal efficiencies of the organic species and the fates of the inorganic species have been documented. The complete results are presented in the full length paper. No organic species were detected leaving the gasification system, and all heavy metals and radionuclide surrogates tested remained in the char residue inside the gasifier.

Radionuclide Studies

Licensing and safety restrictions prevented use of radionuclides in the pilot-scale gasifier. However, radioactive arsenic, mercury, thorium, protactinium, uranium, and neptunium, prepared and analyzed at the University of Missouri Research Reactor, were studied in a laboratory-scale gasifier. With the expected exception of mercury, the radiotracers remained on the gasified char, with less than 1% being found downstream in the condensation trap and char filter. Only 55% of the mercury remained on the spent char in the gasifier. Most of the remainder (41%) was trapped in the char filter, and all of the rest of the mercury was found in various locations downstream from the gasifier but before the char filter. The cold char filter is a very efficient trap for mercury, and absolutely no mercury was detected in the gas product beyond the char filter. Significantly, the radioactive neptunium studied is a transuranic element and a precursor to plutonium, which is its decay product.

References

- 1 "Process for Treatment of Hazardous Wastes by Reverse Burn Gasification," ChemChar Research, Inc., U.S. Patent Number 4,978,477, Dec. 18, 1990.
- 2 "Reverse-Burn Gasification for Treatment of Hazardous Wastes: Contaminated Soil, Mixed Wastes, and Spent Activated Carbon Regeneration," Laura L. Kinner, Audrey

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