United States
Environmental Protection
Agency

Air and Energy Engineering
Research Laboratory
Research Triangle Park NC 27711

Research and Development

EPA/600/S7-86/015d Aug. 1986

EPA

Project Summary

Coal Gasification Environmental Data Summary: Organics

Karl J. Bombaugh

This report summarizes the organics data from environmental assessments of several low- and medium-Btu coal gasification processes conducted between 1977 and 1981 under the sponsorship of the U.S. Environmental Protection Agency. This data summary focuses on the concentration, composition, and mass flow of organics in the major streams of the various gasifier-related processes. Many compounds in the organics from the major gaseous-, aqueous-, and solid-phase streams of the several processes are identified. Organic compositions and stream concentrations among plants and plants' streams are compared.

This Project Summary was developed by EPA's Air and Energy Engineering Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

This report provides a collection and reduction of data that pertain to the organics in coal gasification process and discharge streams. During the past decade, EPA/AEERL has conducted source test and evaluation programs at commercial-, pilot-, and bench-scale coal gasification facilities. The objectives of these programs were to provide test data for:

- characterizing regulated and non-regulated species in process waste streams;
- evaluating pollution control process performance;
- developing sampling and analytical methods for characterizing constituents in process and waste streams;
- evaluating the potential health and ecological effects of process waste streams;
- developing pollution control schemes for treating gaseous, liquid, and solid waste streams;
- providing input to federal, state, and local regulatory agencies; and
- providing input to health studies.

These programs were conducted on several types of gasifiers using different coal feedstocks (Table 1). The facilities were selected based on the greater availability of process, gas, liquid, and solid phase data. Results of these investigations are documented in a number of referenced government reports, symposium proceedings, and journal publications. The tests varied in scope as well as in breadth and dealt with a range of pollutant groups (e.g., trace metals, organics, sulfur species, nitrogen species, and hydrocarbons). Some studies dealt primarily with wastewater; others investigated all types of streams: gaseous, organic liquid, and aqueous- and solid-waste. The data from several of these test sites are distributed over more than one document, so that several documents must be consulted to obtain comprehensive pictures of any pollutant-concern relating to more than one gasifier.

This report presents a compilation of currently available data that relate specifically to the organics levels in the various streams of the several types of coal gasifiers that were investigated

Table 1. *Source Test and Evaluation Program*

Plant	*Gasification Process*	*Fuel*
Fort Snelling	Wellman-Galusha (low Btu)	ND Lignite
Glen-Gery	Wellman-Galusha (low Btu)	Anthracite
Holston	Willputte/Chapman (low Btu)	Bituminous Coal
Kosovo	Pressurized, fixed-bed gasifier	Lignite
Modderfontein	Koppers-Totzek entrained-bed	High Volatile Bituminous Coal
Ptolemais	Koppers-Totzek entrained-bed	Bituminous Coal
Worcester	Riley Gas Producer (low Btu gasifier)	Lignite
Oberhausen-Holten	Texaco entrained-bed	Illinois No. 6 Bituminous Coal
Duluth, University of Minnesota	Foster-Wheeler/STOIC (low Btu gasifier)	Lignite
Madison, PA	Kellogg-Rust/Westinghouse, fluidized-bed process development unit	WY Subbituminous Pittsburgh No. 8 Bituminous Coal ND Lignite
	Other Programs	
Homer City	Bi-Gas Pilot Plant	Pittsburgh No. 8 Bituminous Coal
Sasol 1	Lurgi Mark IV (modified)	KY No. 9 Bituminous Coal

under this program. In addition to presenting a coherent compilation and summary, these data have been consolidated to enable an interpretative evaluation of:

- trends or correlations of organics behavior across processes,
- trends or correlations in the context of control approaches,
- specific characteristics of individual processes, and
- recommendations for monitoring commercial-scale systems to further define environmental issues or apparent trends in pollutant behavior.

This data consolidation and evaluation should make it possible to:

- recognize process-specific characteristics for both synfuels production and pollution control technologies which should influence the areas of emphasis and scope of future monitoring activities including monitoring for Synthetic Fuels Corporation (SFC)-supported facilities, and
- define data interpretation and presentation approaches which will help evaluate the data addressing particular areas of concern in mitigating environmental and health problems with existing and future facilities.

In this report, "organics" refers to any compound, or group of components, that contain both carbon and hydrogen. Compounds containing other elements (e.g., oxygen, nitrogen, and sulfur) in addition to carbon and hydrogen are also considered to be organic.

Objectives

The overall objective of this report is to present information about organics in discharge streams of various coal gasification processes. The streams of concern may be discharged to the environment or to other processes or control modules that in turn have discharge streams. The principal concern here are those streams that may impact the environment. The information considered here was gained from a series of tests conducted on a variety of plants, both pilot- and commercial-scale, over a span of several years using an EPA-approved protocol that evolved during the program. The tests' results contain an abundance of information on pollutants. Because the objective of these tests was to characterize the low/medium Btu coal gasification technology, the tests addressed a broad range of pollutant concerns among which the organics was only one of many.

Results and Conclusions

The conclusions drawn from this evaluation point out similarities and dissimilarities in the gasification processes reviewed. The major similarities in the data are:

- the tar-producing gasifiers, operated on coal with similar volatiles content, produced about 30 kg of condensable organics in the product gases per metric ton of feed coal;
- these organics generally were similar in composition; and
- none of the gasifiers showed a significant trend toward the production of any specific class of compounds or species (hazardous or nonhazardous).

The data indicate that the five tar-producing gasifiers (Chapman, Wellman-Galusha [Fort Snelling], Riley, Foster-Wheeler/STOIC, and the Lurgi-type [Kosovo]) produce similar amounts of similar kinds of organics. However, these data depend on the analytical techniques employed. Hundreds of components were detected, many species were identified, and many identifications were made at the component class or subclass level (e.g., alkyl benzenes). The total identification of these components was far from complete as would be expected from the survey nature of these studies. The non-polar organics identified were primarily paraffins (including long straight chain paraffins), aromatics (benzenes, alkyl benzenes, naphthalenes, and alkyl naphthalenes), and polycyclic aromatics (including alkyl polycyclic aromatics and polycyclic hydro-aromatics). The polar organics consisted of hydroxy-aromatics (phenols and alkyl phenols), aromatic amines, and nitrogen heterocyclics. The organics contained lesser amounts of heterocyclic compounds containing oxygen, sulfur, and multi-heterocyclic compounds (e.g., thiazoles).

Detailed analyses tended to be predirected to known components of concern such as priority pollutants or selected polynuclear aromatics and were generally limited to single column gas chromatography-mass spectrometry without additional separation and confirmation. Speciation was not consistent across the data base, and no valid comparison of species distribution across the gasifiers as a group can be made. This limitation is made more severe in several cases because the mass of an extensive list of identified compounds represented less than 10 percent of the total organic mass in a stream. For the Chapman gasifier, however, relatively few components comprised the major portion of the speciated mass. Overall, the speciations do not provide a complete statement of composition for the organics arising

from the gasification process, but they do identify and quantify many species considered to be environmentally significant. Additional compounds of equal or greater significance also may have been present. The gasifiers surveyed displayed some dissimilarities which, in general, were substantiations of the overall behavior of organics in gasification processes.

The organics in the crude product gas result largely from thermal devolatilization of coal. Therefore, it is not surprising that the product gas from the Wellman-Galusha gasifier (Glen-Gery), operated on anthracite, contained virtually no condensable organics. The bottom gas from the Foster-Wheeler/STOIC gasifier which is produced from the coked coal was also practically organics-free. The entrained-bed processes (Texaco, KRW, and Koppers-Totzek) force the devolatilized material to pass through the gasification zone so their product gases were also much lower in condensable organics. Trace amounts of phenol were found in the aqueous streams from these processes. It is also noteworthy that the organic loadings of the ash from the tar-producing gasifiers were all between 300 and 600 ppm except for the Foster-Wheeler/STOIC which was only 1 ppm.

Hydantoins were not detected (<2 ppm) in wastewater from the Kosovo Lurgi-type (dry ash fixed-bed) gasifier, although they were found at high levels (300-3000 ppm) in wastewater from another fixed-bed gasifier.

Several conclusions concerning the environmental significance of organics in product gas can be made from the collected data. Organics in crude product gas can impact the environment either by escaping from the process through a discharge stream or a leak or by increasing the level of pollutants in combustion flue gas.

The impact of organics escaping to the environment is a process-specific and a stream-specific problem because the composition of the organics mixture is influenced by temperature and by contact with both aqueous and organic solvents. For example, at the Chapman site the organics discharged from the stripper vent (45 percent VO) were different from the organics trapped from either the crude gas (16 percent VO) or the tar (5 percent VO).

Selective treatments, such as at Kosovo where a combination of aqueous scrubbing, selective gas cleaning (Rectisol), and selective water cleaning (Phenosolvan) are used, alter the organic composition considerably. Lipophilic components were enriched in the naphtha and medium oil, while the hydrophilic components were concentrated in the water and accumulated in the crude phenol. Both types of components were concentrated, to some extent, by the thermally condensed tar. In such a system, the composition of the condensable or extractable organic is stream specific.

A survey of organic mass loading can indicate the potential for pollution from a source, but it can neither describe the composition nor define the risk potential. LC fractionation as used in this study can indicate if the bulk of the organics is primarily polar or non-polar, but more detailed analyses are required to assess the severity of pollution or the potential for environmental effects. Nevertheless, organic composition and mass loading data provide valuable information for use in environmental control technology.

K. J. Bombaugh is with Radian Corporation, Austin, TX 78766.
***William J. Rhodes** is the EPA Project Officer (see below).*
The complete report, entitled "Coal Gasification Environmental Data Summary: Organics," (Order No. PB 86-209 095/AS; Cost: $16.95, subject to change) will be available only from:

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650

The EPA Project Officer can be contacted at:

Air and Energy Engineering Research Laboratory
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

United States
Environmental Protection
Agency

Center for Environmental Research
Information
Cincinnati OH 45268

Official Business
Penalty for Private Use $300
EPA/600/S7-86/015d