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EPRI EL-5944
Project 2028-15
Final Report
July 1988



Pyrolysis and Combustion Products of Selected Utility Materials

Prepared by
Midwest Research Institute
Kansas City, Missouri

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REPORT SUMMARY

SUBJECTS: Transmission substation design and operation / Hazardous and toxic waste management

TOPICS:
- Fires
- Electrical insulation
- Chemical analysis
- Capacitors
- Transformers
- Construction materials

AUDIENCE: Environmental managers / Transmission and distribution engineers

Pyrolysis and Combustion Products of Selected Utility Materials

This project assessed the potential effects of fires in electrical equipment to determine the chemicals produced by burning materials such as laminates and epoxies. Pyrolysis and combustion experiments showed that the by-products studied were in many cases similar to compounds formed by the burning of common materials such as maple wood, with resulting toxicity levels significantly lower than those from PCB fires.

BACKGROUND

Widespread utility concern about the formation of polychlorinated dibenzofurans (PCDFs) in polychlorinated biphenyl (PCB) fires has resulted in extensive field and laboratory documentation of such fires (EPRI report CS-3308). However, no systematic analyses exist for by-products of fires involving other insulations and materials used by electric utilities. Comparing the thermal degradation products of these materials with those of maple wood, a commonly burned substance, and with PCDFs resulting from PCB fires provides a relative indication of potential toxicity.

OBJECTIVES

To identify and roughly quantify thermal degradation products of several materials used in electrical equipment, including maple wood; to compare the thermal degradation products of these materials with those from PCB.

APPROACH

The utility materials analyzed included kraft paper, kraft-phenolic laminates, PCB replacement fluids, Nomex, epoxies, creosote, and several types of cable insulation. Maple wood served as a benchmark substance to assess whether the materials pose any unique human health hazards when burned. For their analyses, the project team used a thermal degradation unit linked to a high-resolution gas chromatographic–mass spectroscopic analytic system. Because screening analyses identified polyvinyl chloride (PVC) as a prime candidate for in-depth thermal degradation analysis, the team subjected several samples of PVC to a broader range of temperatures and test conditions. Previous field and laboratory documentation of PCDF formation in PCB fires provided data for comparison.

RESULTS

Pyrolysis and combustion of the utility materials produced, in the worst cases, compounds with toxicities significantly lower than PCDF. Thermal

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degradation of many utility materials and maple wood produced relatively similar compounds.

EPRI PERSPECTIVE

This study supplements related work, described in EPRI reports EL-4503 and EL-5262, on fluid substitutes to replace PCB in transformers and capacitors. Although the utility materials analyzed in this study produced a number of compounds classified as carcinogens when combusted or pyrolyzed, natural substances such as maple wood formed similar by-products under the same conditions. Further, tabulated toxicities of even the most toxic of the utility materials were still considerably below PCDF toxicities (see the *Registry of Toxic Effects of Chemical Substances* issued by the U.S. Department of Health and Human Services for 1981–1982 and later editions). A related EPRI report, EL-4939, contains a literature review of pyrolysis and combustion products of selected utility materials.

PROJECT

RP2028-15
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Pyrolysis and Combustion Products of Selected Utility Materials

EL-5944
Research Project 2028-15

Final Report, July 1988

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Research Project 2028-15

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ABSTRACT

A variety of utility materials, such as papers, dielectric fluids, insulation materials, and polymers, were studied to evaluate their potential to generate undesirable thermal degradation products under fire conditions. A combined pyrolysis-gas chromatography/mass spectrometry (Py-GC/MS) system was used to pyrolyze and/or combust the materials followed by GC/MS analysis of their products. Products were tentatively identified by computerized library searches and by manual interpretation. The pyrolysates of the utility materials were compared with those produced by maple wood. Those materials of similar structure to maple wood--Kraft papers, pressboard, and rag paper decompose yielding common products with the maple wood. Materials containing only carbon, hydrogen, and/or oxygen other than the wood derivatives, Midel, polyethylene, Edisol, and Wamcol, produce primarily alkanes, alkenes, alkylated benzene derivatives, and some polycyclic aromatic hydrocarbons (PAHs) that are characteristic of the bulk material. Those materials containing heteroatoms other than carbon, hydrogen, and oxygen, such as nitrogen or sulfur, typically produce unique thermal decomposition products that are characteristic of the original material. Creosote yields a complex mixture of PAHs, nitrile rubber produces nitriles and alkylated benzenes, and Nomex produces several molecules that contain nitrogen, but are not identifiable using the present methods. The nonvolatile chlorine-containing materials, PVC and Electrochem, produce chlorobenzenes and are therefore potential precursors of larger, more highly chlorinated molecules that are of current environmental interest.

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PREFACE

This report presents the results of screening for pyrolysis and combustion products of utility materials. The goal of the project conducted for the Electric Power Research Institute (EPRI) is to evaluate the potential of utility materials to generate undesirable thermal degradation products under fire conditions. The objective of the work summarized in this report is to identify the significant pyrolysis and combustion products of selected utility materials and to elaborate on more in-depth experimental work and data interpretation for one of these materials (PVC).

This work was done on EPRI Contract No. RP2028-15 (MRI Project No. 8538-A) between September 1986 and December 1987. This final report describes the experimental work carried out on this contract. An Interim Report entitled "Literature Review of Pyrolysis and Combustion Products of Selected Utility Materials" (November 1986) described the results of the literature review portion of this program.

The report was prepared by Thomas M. Sack, with assistance from Laura Wyatt. Samples were prepared for the pyrolysis-gas chromatography/mass spectrometry (Py-GC/MS) experiments by Mr. Scott Meeks. The Py-GC/MS experiments were conducted by MRI mass spectrometrists Frederick Foreman, Leslie Moody, Kelly Thornburg, Margaret Wickham and Audrey Zoog; data were interpreted by Mr. Meeks, Kelly Thornburg, and Dr. Sack. Alicia Rogers provided word processing support for this report.

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SUMMARY

This report contains the results from a study designed to evaluate the potential of various utility materials to generate undesirable thermal degradation products during a fire. The materials tested are summarized in Table S-1 and include polymers, rubbers, adhesives, films, fluids, and coatings that are commonly used in utility devices. Materials were selected for study on this project based upon a literature review (EPRI Report No. EL-4939) performed at MRI as an earlier phase of this project, discussions with the EPRI project advisory panel, and a questionnaire given to the members of the advisory panel and selected EPRI personnel. In addition, through periodic meetings of the advisory panel, one of the materials, polyvinyl chloride (PVC), was selected for more in-depth study of its thermal degradation products due to the potential of PVC for formation of chlorinated aromatic species upon pyrolysis. In addition, maple wood was chosen as a benchmark to represent a material that produces pyrolysis/combustion products that are considered to be relatively harmless. Therefore, maple wood was also subjected to the same screening tests as the other materials so that the thermal degradation products of the utility materials could be compared with those of a commonly used material that is perceived to present no significant hazards.

The materials were screened by conducting pyrolysis (thermal degradation in an inert atmosphere) and combustion (thermal degradation in air) experiments at two temperatures, 500° and 900°C. Those materials studied only during the early phase of this work were screened only by pyrolysis at 900°C and are flagged in Table S-1. The products of thermal degradation were separated and analyzed by the technique of combined gas chromatography/mass spectrometry (GC/MS). Each pyrolysis/combustion product was tentatively identified on the basis of its mass spectrum by computerized data base searches and by manual interpretation.

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Table S-1

MAJOR UNIQUE PRODUCTS OF UTILITY MATERIALS
SUBJECTED TO THERMAL DEGRADATION TESTS AT MRI

Material	Screening Level[a]	Major Unique Product(s)[b]
Polyvinyl chloride (PVC)	F	Anthracene, tetrachloroethylene
Formel NF	F	Tetrachlorodifluoroethane
Wecosol	F	Tetrachloroethylene
Electrochem FR-15	F	Chlorobenzenes
Dicy.-treated Kraft paper	F	None
Dicy.-treated crepe paper	M	Methylbutenal
Nitrile rubber	F	Organic nitriles
Nomex 411 paper	F	Unknown, dimethylethyl-cyclohexadienedione
Creosote	F	$C_{11}H_{10}$, naphthalene
Kraft pressboard	M	C_6H_8O, methylbutenal
Kraft paper	F	None
Rag paper	M	C_6H_6O, furanylethanone
Kraft phenolic laminate (Herkolite)	M	Alkylphenols
Kraft phenolic laminate (Spauldite)	M	Alkylphenols
Formex wire enamel	M	C_5-Alkylbenzenes
Wemcol (new)	F	C_3-Alkenylbiphenyls
Wemcol (used)	F	C_3-Alkenylbiphenyls
Ediso1 III	F	$C_{15}H_{16}$
Polyethylene	F	Alkenols, alkylbenzenes
Midel 7131	F	Nonanone, C_3-alkylbiphenyls

[a] F = full thermal screening in helium and air at 500° and 900°C;
M = modified screening in helium at 900°C only.

[b] Major pyrolysis/combustion product(s) unique to this material relative to maple wood.

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The results indicate that the utility materials commonly yield a very complex set of thermal degredation products that are characteristic of tha bulk material. The exceptions include the liquid materials, Formel, Wecosol, Electrochem, Wemcol, Edisol, and creosota, which were found to preferentially volatilize rather than thermelly decompose in the instrumental system used for this work. Therefore, the products observed for these materials are predominantly not thermal decomposition products, but the constituents of the bulk material. Table S-1 includes a list of those major pyrolysis/combustion products for each material that are unique reletive to meple wood. The reeder must be cautioned when comparing the results of this study to other studies involving pyrolysis or combustion, as the literature review (EPRI Report No. EL-4939) revealed that there is significant variation of the results obtained from different laboratories. The information provided in this report should therefore be interpreted as only an approximate model of the behavior of the utility materials in actual fires as it is not possible to construct an accurate laboratory model of a fire.

CHLORINE-CONTAINING MATERIALS

The chlorine-containing substances, polyvinyl chloride (PVC), Formel, Wecosol, and Electrochem, yield thermal degradation products that have incorporated chlorine into relatively small molecules (e.g., chlorobenzenes and polychloroethenes). The products from the liquid materials in this category, Formel, Wecosol, and Electrochem, are likely to be the components of the material rather than thermal degradation products for the reason discussed above. The PVC, on the other hand, was found to decompose into benzene, and to a lesser extent, larger polyoylic aromatic hydrocarbons (PAHs) that are commonly produced by other combustion sources, such as internal combustion engines and incineration. The fact that PVC does form low levels of chlorinated benzenes and is reported to produce copious amounts of HCl indicates that it has the potential to produce the lerger polychlorinated chemical species such as PCBs, PCDDs, and PCDFs upon extended reaction. However, none of the larger chlorinated species listed above were observed to be produced above the part-per-million yield level detection limit in this work.

NITROGEN-CONTAINING MATERIALS

The materials containing nitrogen include the dicyandiamide-treated papers, Nomex, creosote, and nitrile rubber. The treated papers, although expected to produce some nitrogenated species upon thermal decomposition, did not appear to react any diffarently than the untreated papers or the maple wood.

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The creosote, which is a liquid composed of a complex mixture of PAHs, yielded abundant PAHs upon thermal degradation. Nitrile rubber yields a considerable number of alkylated benzene derivatives, which are also produced by maple wood but at much lower levels, PAHs, and low levels of organic nitrile compounds. The Nomex paper was expected to produce species characteristic of Nomex, but was observed to yield products that are not readily identified by the methods used in this work. Because these products were not identified, Nomex is recommended for further study using additional chemical identification tools.

MATERIALS CONTAINING ONLY C, H, AND O

The final category of utility materials tested on this program included those materials having only carbon, hydrogen, and/or oxygen in their structures. The untreated papers are included in this category, and as they have compositions similar to maple wood, they produced thermal degradation products that are characteristic of wood, cellulose, and lignin. Those materials containing significantly different compositions from maple wood (Herkolite, Spauldite, Formex enamel, Wemcol, Edisol, polyethylene, and Midel) tended to decompose into more unique products that may be considered to be of more concern due to the fact that they are not combustion products of common woody materials.

Each liquid material yielded products very similar to the bulk material and therefore are of no more concern than the utility material itself. However, note that in the present instrumental system, the liquids may have been incompletely pyrolyzed. Therefore, these results may not be representative of a real fire in which sample residence times and temperatures may be significantly different than those used here. The solid materials, Herkolite, Spauldite, and polyethylene, were cleanly pyrolyzed and combusted, yielding a complex array of products. In each case, products consisted of alkylated benzenes, aliphatic and aromatic hydrocarbons, and a few oxygenated species, but did not appear to represent any chemical classes different than those produced by maple wood.

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Section 1

INTRODUCTION

BACKGROUND

The goal of this project was to evaluate the potential of utility materials to generate undesirable thermal degradation products under fire conditions. Solid, liquid, and gaseous materials used in electrical equipment could degrade under fire conditions. These materials include polymers, rubbers, adhesives, films, fluids, and coatings. The materials are used for electrical insulation or construction (gaskets, wood preservation, etc.). The liquids of interest include PCB-substitute dielectric fluids for transformers and capacitors.

The materials selected for study on this project were selected based on a literature review, a questionnaire, and discussions with the EPRI project advisory panel. The literature review (1) was conducted as an earlier phase of this project. The review addresses the published literature, primarily from 1967 to the present, on the pyrolysis, combustion, or other thermal degradation processes of 26 utility materials. The materials are grouped according to their chemical composition, that is, by whether they contain chlorine, fluorine, nitrogen, sulfur, or only carbon, hydrogen, and/or oxygen. The literature review illustrates that the results of thermal decomposition experiments are highly dependent on the experimental conditions. Thus, comparisons of results from different studies will be difficult and will require great care to prevent overinterpretation of the data.

In addition to the literature review, two other sources of information on utility materials were used to prioritize the materials. On March 12, 1986, a questionnaire was sent to the members of the advisory panel and selected EPRI employees to gather information on the uses and perceived problems associated with the candidate materials. In addition, discussions at quarterly review meetings have been most informative and have provided valuable direction in the prioritization of the materials to be studied. The materials selected for testing at MRI are given in Table 1-1.

Table 1-1

MATERIALS ANALYZED BY PY-GC/MS AT MRI

Material	Major Component(s)
Kraft paper	Cellulose
Dicy.-treated Kraft paper	Cellulose, dicyandiamide
Rag paper	Cellulose
Dicy.-treated crepe paper	Cellulose, dicyandiamide
Kraft pressboard	Cellulose, binders
Kraft phenolic laminate (Herkolite)	Cellulose, phenolic resins
Kraft phanolic laminate (Spauldite)	Cellulose, phenolic resins
Formex wire enamel	Naphtha, enamels
Black Nitrile rubber	Rubber, acrylonitrile
Wemcol (new)	Isopropylbiphenyl
Wemcol (used)	Isopropylbiphenyl
Edisol III	C_3-Alkylbiphenyls, phenylxylethane
Polyethylene	
Maple wood	Cellulose, lignin
Formel NF	Tetrachloroethylene, freons
Midel 7131	Pentaerythrital esters
Polyvinyl chloride (PVC)	
Nomex 411 paper	Cellulose, m-phenylenediamine, isophthalic acid polymer
Creosote	Complex mixture of aliphatic, aromatic, and heterocyclic hydrocarbons
Wecosol	Tetrachloroethylene
Electrochem FR-15	Mixture of tri and tetrachlorobenzenes

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Upon the completion of the screening experiments, a review meeting was held at which the material for in-depth study was selected on the basis of its screening results and potential for production of unique thermal degradation products. PVC was chosen for the in-depth study because it is a halogenated material that has the potential to produce chlorinated aromatic species upon thermolysis that may further react with atmospheric oxygen to form heterocyclic halogenated aromatic molecules.

OBJECTIVE

The objective of this program is to identify the significant pyrolysis and combustion products of selected utility materials (see Table 1-1) and to provide more in-depth experimental work and data interpretation regarding the thermal behavior of polyvinyl chloride.

EXPERIMENTAL OVERVIEW

In order to screen many materials under both pyrolysis and combustion conditions, an on-line pyrolysis/analysis system was used under a limited set of conditions. The CDS pyroprobe pyrolysis and trapping system which can be used to pyrolyze or combust small samples of liquids or solids in a batch mode was used for all screening experiments. The thermal degradation conditions were set to heat the sample as rapidly as possible and rapidly sweep the products from the thermal reaction zone into a trapping system. The rapid heating and short residence time minimized the secondary reaction products. The thermal degradation products were subsequently analyzed by a high resolution (capillary column) gas chromatograph/electron impact mass spectrometer (GC/MS).

Qualitative product identifications were made with the assistance of a computer search program and mass spectral data base. The computer identifications were manually reviewed and further refined; however, extensive detailed interpretations by spectrometrists were not conducted. Additional product identifications could be made if additional time was devoted and sample reruns were conducted.

For some of the materials screened during the latter part of the program, products yields were roughly quantified in addition to qualitative identification. The basic experimental approach is identical to the qualitative work performed earlier

in this project, except that an external standard, anthracene, is analyzed and used to estimate semiquantitatively the yields of the thermal degradation products. The experimental details for all of the work performed on this program are presented in Section 2.

ORGANIZATION OF THE REPORT

The remainder of this report describes the experimental details, results and discussion, and quality assurance for the experimental work carried out under this contract.

Appandix A contains complete tables of the individual products identified in each thermal degradation experiment carried out during this work. Summary tables of the pyrolysis and combustion products, arranged by compound class, for the utility materials are presented in Appendix B.

Section 2

EXPERIMENTAL

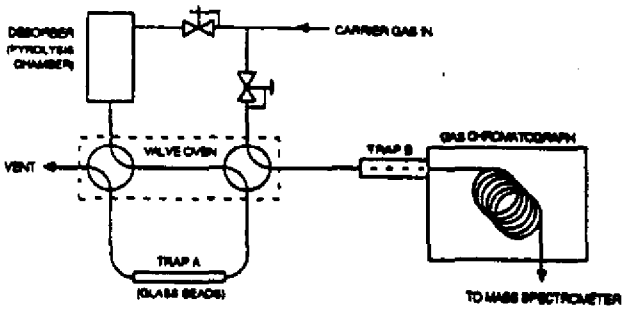
APPARATUS

Thermal degradation experiments (pyrolysis and combustion) were conducted using a Chemical Data Systems Model 122 Pyroprobe (filament pyrolyzer) and Model 330 concentrator unit (see Figure 2-1). The pyrolysis/concentrator system was interfaced directly to each GC/MS system by a heated capillary transfer line of fused silica. A zero dead-volume butt connector linked the transfer line to the analytical GC column. Several GC/MS systems were used in these studies: Finnigan/MAT 4000 quadrupole HRGC/MS; Finnigan/MAT 5100 quadrupole HRGC/MS; Kratos MS50TC double-focusing MS interfaced to a Carlo Erba MFC500 capillary GC; and Finnigan/MAT 311A and 312 double-focusing mass spectrometers coupled to Hewlett Packard 5890A and Varian 3700 GCs, respectively. Data acquisition and reduction were performed exclusively on Finnigan/INCOS mass spectrometry data systems. The instrumental parameters used for each system are summarized in Table 2-1. Semiquantitative analyses were performed exclusively on the Finnigan/MAT 5100 and 311A systems.

In addition to the CDS pyroprobe, an SGE Pyrojector (furnace pyrolyzer) was used for the in-depth studies of PVC (see Figure 2-2). The Pyrojector was interfaced to the Finnigan/MAT 4000 quadrupole GC/MS system by attachment to the standard split/splitless injector of the GC through a restrictor needle.

Experiments using the Pyrojector employed the same GC and MS conditions outlined in Table 2-2 for the Finnigan/MAT 4000 GC/MS. However, the negative chemical ionization (NCI) experiments were carried out with methane as the reagent gas at approximately 0.1 torr along with the use of negative ion detection electronics. For the NCI experiments, a scan rate of 1 s/scan over the mass range of 100-675 amu was used.

STEP 1: PYROLYSIS AND TRAP



STEP 2: CRYOFOCUS, DESORB, AND ANALYZE

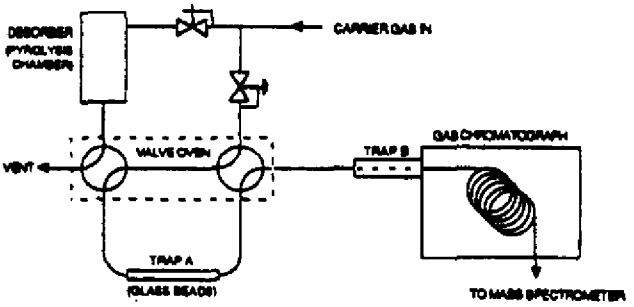


Figure 2-1. Schematic Diagram of the Filament Py-GC/MS Apparatus

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Table 2-1

EXPERIMENTAL CONDITIONS FOR PY-GC/MS ANALYSES

	Finnigan MAT 4000	Finnigan MAT 5100	Kratos MS50TC	Finnigan MAT 311A	Finnigan MAT 312
Ion source	250°C	~ 150°C	280°C	280°C	280°C
Resolution	Unit	Unit	1500[a]	600[a]	650[a]
Electron energy	70 eV	70 eV	70 eV	700 eV	70 eV
Emission current	400 µA	500 µA	500 µA	2 mA[b]	2 mA[b]
Electron multiplier voltage	-1550	-1350	-1000	-1400	-1500
Sensitivity	10^{-6} A/volt	10^{-6} A/volt	NA[a]	NA[a]	NA[a]
Scan range	40-500 amu	40-500 amu	40-500 amu	51-443 amu	51-443 amu
Scan time	1 s	1 s	1 s	1.5 s	1.7 s
GC	Finnigan 9610	Finnigan 9611	Carlo Erba HRGC500	Hewlett Packard 5890	Varian 3700
Injector temperature	280°C	280°C	280°C	280°C	280°C
Transfer line temperature	280°C	280°C	280°C	280°C	280°C
GC column	30 m DB-5	60 m DB-5	60 m DB-5	60 m DB-5	60 m DB-5
GC program					
Initial temperature	50°C	50°C	50°C	50°C	50°C
Initial hold	2 min	2 min	2 min	2 min	2 min
Ramp	10°C/min	10°C/min	10°C/min	10°C/min	10°C/min
Final temperature	300°C	300°C	300°C	300°C	300°C
GC carrier	He, 10 psi	He, 24 psi	He, 24 psi	He, 24 psi	He, 24 psi
Transfer line temperature	300°C	300°C	300°C	280°C	280°C
Desorber temperature	300°C	300°C	300°C	300°C	300°C
Valve oven temperature	300°C	300°C	300°C	300°C	300°C
Trap A (glass beads)[c]	-100/300°C	-100/300°C	-100/300°C	-100/300°C	-100/300°C
Trap B (glass beads)[c]	-100/300°C	-100/300°C	-100/300°C	-100/300°C	-100/300°C
Reactant gas flow[d]	30 mL/min	30 mL/min	30 mL/min	30 mL/min	30 mL/min
Pyrolysis time	4 min	4 min	4 min	4 min	4 min
Trap A time	10 min	10 min	10 min	10 min	10 min
Trap B load time	15 min	20 min	20 min	20 min	20 min
Trap B desorb time	10 min	10 min	10 min	10 min	10 min

[a] NA = not applicable.

[b] Total electron current.

[c] Values shown correspond to trap temp/desorb temp.

[d] Flow rate of gas flowing through pyrolysis chamber (desorber).

[e] 10% valley resolution.

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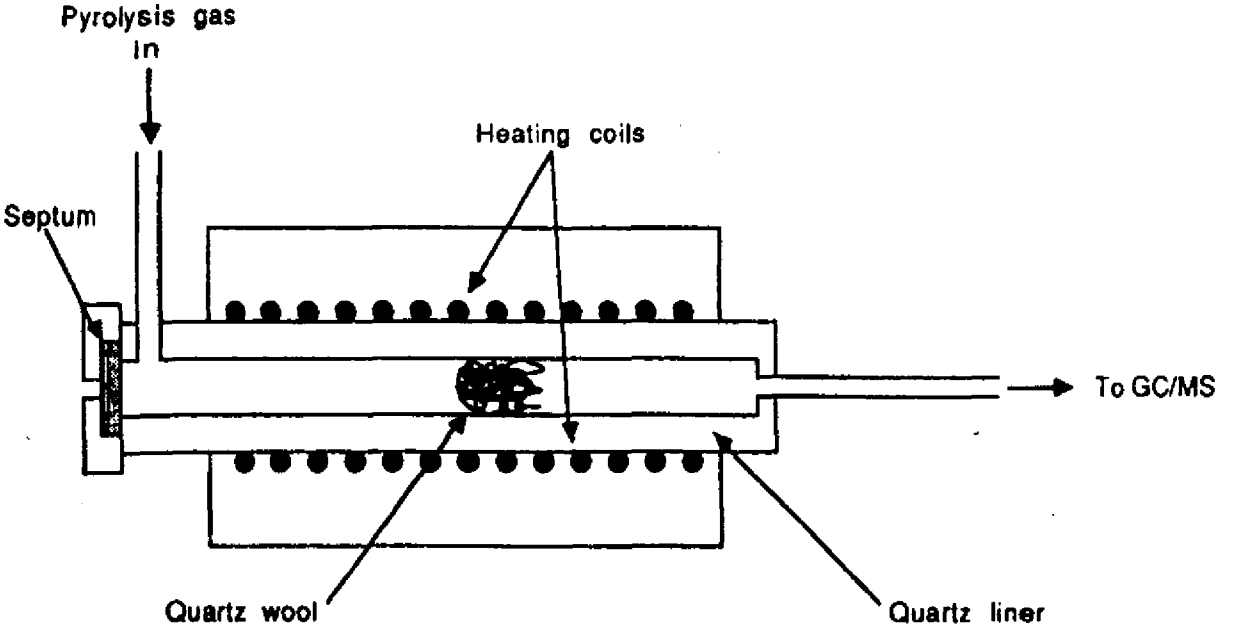


Figure 2-2. Schematic Diagram of the Furnace Pyrolyzer

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Table 2-2

EPRI SAMPLE RECORD

Sample ID#	Sample Description
8638-012786-01	TOR-1 Dicy. Treated Kraft Paper
8638-012786-02	TOR-2 Kraft Paper
8638-012786-03	TOR-3 Rag Paper
8638-012786-04	TOR-4 Dicy. Treated Crepe Paper
8638-012786-05	TOR-5 Kraft Pressboard
8638-012786-06	TOR-6 Kraft-Phenolic Lam.(Herkolite)
8638-012786-07	TOR-7 Kraft-Phenolic Lam.(Spauldite)
8638-012786-08	TOR-8 Formex Wire Enamel
8638-012786-09	TOR-9 Black Nitrile Rubber
8638-020786-01	Poly(vinylchloride) 9038 v(specific=1.38
8638-021586-01	Epoxy Catalyst GE-A80P328A1
8638-021586-02	Epoxy Resin/Green GE-A80P328A1
8638-021586-03	Acrylic Lacquer/Yellow GE-Premium
8638-021586-04	Epoxy Resin/Grey GE-A80P328A1
8638-021586-08	Acrylic Lacquer/Green GE-A8B4881
8638-021586-09	Polyester Powder/Grey GE-A8B4SIX
8638-021586-07	Coal Tar Epoxy Resin GE-A80P328A1
8638-021586-08	Coal Tar Epoxy Catalyst GE-A80P328A1
8638-021586-09	Cold Galvanizing Compound GE-LRC
8638-021586-10	Epoxy Resin/Green GE-A8B418[illegible]
8638-021586-11	Epoxy Catalyst GE-A8B418[illegible]
8638-021586-12	Urethane Powder/Grey GE-A8B4881
8638-021586-13	Epoxy Powder/Green GE-A8B48A1
8638-021586-14	Epoxy/Urea Form.Resin/Grey GE-A8B4083
8638-021586-15	Epoxy/Urea Form.Resin/Green GE-A8B4082
8638-021586-16	Phenoxy/Green GE-Premium
8638-021586-17	Urethane Resin/Grey GE-A8B60A2
8638-021586-18	Urethane Catalyst GE-A8B60A1
8638-021586-19	Urethane Resin/Green GE-A8B30A1
8638-021586-20	Acrylic Lacquer/Grey GE-A8B4885
8638-021586-21	Acrylic Lacquer/Grey-Tan GE-A8B4884
8638-030186-01	35KV Cable-CPE Insul. Union Carbide=4201
8638-030186-02	35KV Cable-LPE Jacket Dow=888
8638-030186-03	35KV Cable-Shield Union Carbide=0680
8638-032586-01	Wemco-Kenh Chemical
8638-032586-02	Edisol III- McGraw-Edison
8638-061786-01	Vecocl Fluid-West Capacitor
8638-061786-02	Edisol II Fluid-McGraw-Edison Capacitor
8638-061786-03	Dielektrol Fluid-GE Capacitor
8638-061786-04	Solestrol Impregnant-Sangamon Capacitor
8638-062586-01	Maple Wood
8638-073186-01	Formel NF 150 Chemicals Ltd Bristol,Eng.
8638-073186-02	MIDEL 7131 Reichhold Chemicals PA.
8638-081886-01	ASEA Paradel Capacitor No. T.1001/8-18
8638-102086-01	Okonite EP Cable
8638-102086-02	Southwire 4/0 600V Underground Cable
8638-102086-03	Integral 2 in.dia. Flexible Cable - HPDE
8638-102086-04	Fiberglass Guy Strainer
8638-102086-05	Epoxy Resin-Ciba Geigy 6005/Araldite 855
8638-102086-06	Epoxy Resin - Ciba Geigy 6005/HHA
8638-102086-07	Nomex Paper (Nomex 410?)
8638-102086-08	Nomex 411 Paper
8638-102086-09	Creosote - Reilly Tar & Chemical
8638-111386-01	VECDBDL-Perchloroethylene Trans. Fluid
8638-111386-02	Electrotherm FR-15 - Chlorobenzene Mix
8638-111386-03	CAN-TEX 2GP-33 Rigid PVC Conduit
8638-870123-01	PVC Conduit-ASTM(D1785 NSF-sw D2565)
8638-870123-02	RTemp HTH Dibenzyl Fluid

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SAMPLE RECEIPT

The materials to be studied were received starting in January of 1986. The record of their receipt is shown in Table 2-2. This table lists a sample ID assigned according to date of receipt along with a sample description.

The sample ID has three fields. The first four-digit field, containing the number 8538, is the MRI in-house project number. The next field of six digits represents the date of receipt. Samples received in 1987 begin with 87 in the second field to facilitate sorting in the sample-tracking system. The last two digits are sequentially numbered up to the total number of samples received on that date.

SAMPLE PREPARATIONS

For the semiquantitative studies approximately 20-100 µg of the solid materials were weighed out on a Cahn/Ventron Model 27 microbalance to the nearest microgram (10^{-6} g) and placed in clean quartz pyrolysis tubes with clean quartz wool on either side. Samples were not cleaned prior to testing to avoid any problems that could be introduced by the use of a cleaning agent, and to preserve the state of the materials as they may be used in a utility device. Prior to the semiquantitative work, small bits of samples estimated to be between 50 and 500 µg were tested. Liquid materials were dispensed onto acidic alumina (Bio-Rad AG-4 100-200 mesh), which had been previously extracted with methylene chloride and oven dried, enclosed in a quartz tube with quartz wool on either side. Measured volumes of the liquids were dispensed using a Hamilton Model 801RN 10-µL syringe.

Sample preparation for the co-pyrolysis experiments involving PVC, EPR, and rust simply involved the placement of a small piece of each material in the quartz pyrolysis tubes together.

The external standard solution was prepared by the dissolution of 2.81 mg of anthracene (RFR Corp., Hope, Rhode Island) in 50.0 mL of isooctane. This yielded a working solution concentration of 56.2 ng/µL for the semiquantitative work.

For the Pyrojector experiments during the in-depth study of PVC, 20 to 100-µg samples of the materials were inserted into the hot zone of the pyrolyzer by the use of a solids injector.

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PYROLYSIS AND COMBUSTION EXPERIMENTS

The pyrolysis and combustion experiments were conducted by loading a pyroprobe with the prepared sample. A platinum ribbon probe was used for the experiment involving one sample, the relatively viscous TOR-8 (Formex wire enemel). A very small spot of TOR-8 was dabbed onto the ribbon. All other experiments were performed with the pletinum coil pyroprobe in which the prepered quartz sample tubes were mounted. Both probes were cleaned prior to each run by heating in air to 1000°C for several seconds.

After the pyroprobe wes inserted into the desorben, the thermel decomposition experiment wes begun (refer to Figure 2-1, Step 1 end Figure 2-3 for the event sequence). The pyroprobe is rapidly heeted (> 20°C/ms) in the desorber to the indicated temperature in a reactant ges atmosphere of helium (pyrolysis) or prepurified air (combustion). The thermel decomposition products were swept by the reectent gas through a gless beed trep (trap A) cooled with liquid nitrogen te -100°C. The decomposition products thus trapped were then transferred to trap B (refer to Figure 2-1, Step 2), where they were cryogenically focused on the heed of the analytical capillary column. The GC/MS analysis began when trap B wes heated rapidly to 300°C to "inject" the thermel decomposition products onto the enalytical column.

Pyrolysis and combustion experiments involving the Pyrojector began by setting the furnace temperature, establishing the reactant gas flow for 1-2 min, injecting the semple, and beginning the GC/MS anelysis. When eir was used as the reactant gas, the GC/MS program was delayed until helium flow was reestablished to the GC column.

ANALYSIS SEQUENCE AND RECORDS

For the majority of this work, the following sample analysis sequence wes followed: first, the normal mass spectrometer setup, tuning, and calibration against FC-43 or PFK was performed according to in-house stendard opereting procedures. Next, semple enalysis began. Typically, the four runs (two temperatures, two atmospheres) for a single material were run sequentially so that any cross-contamination would be confined to tha same starting materials. Anthracene external standards were run after every four samples or between different starting materials during the semiquatnitetive work. Anthracene external standards were not used for the in-depth charecterization of PVC experiments. System blanks were run at the discretion of the instrument operator after any sample runs which indicated potential cross-contamination.

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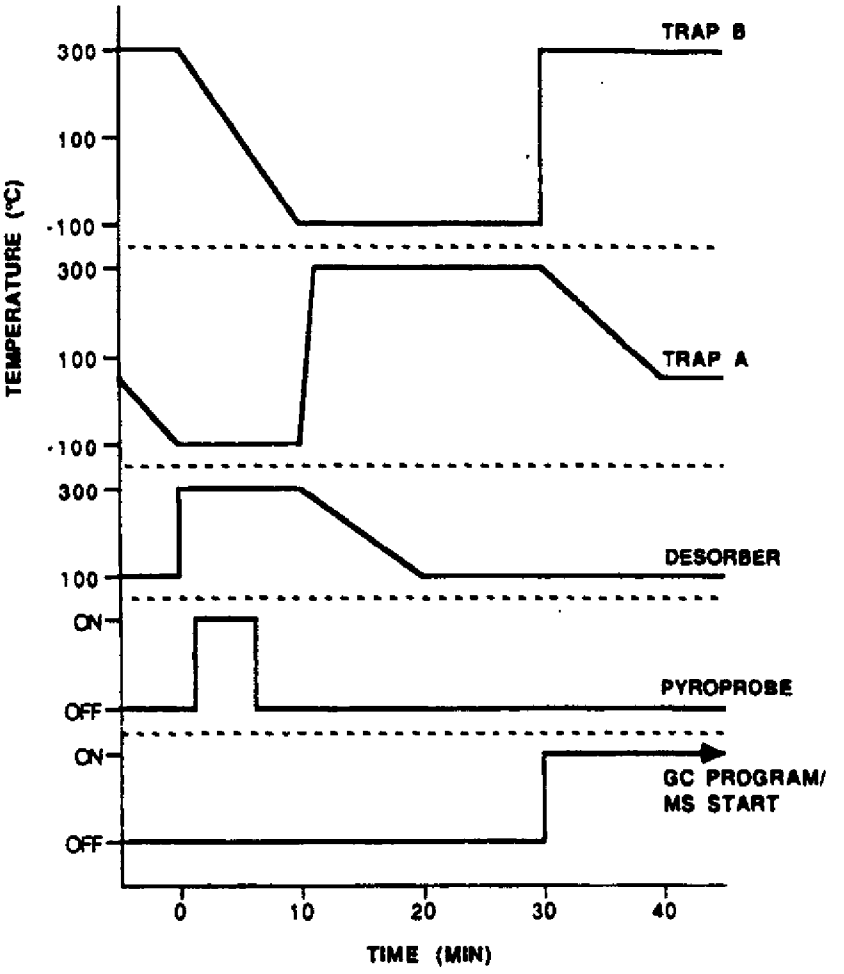


Figure 2-3. Sequence of Events for Py-GC/MS Experiments

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DATA REDUCTION

Each Py-GC/MS data file was processed first by the INCOS data system, which made a list of significant GC peaks. The GC/MS analyst then examined the list and added to it any significant GC peaks that the INCOS system had missed. The INCOS system was then used to plot the enhanced mass spectrum and the INCOS library search results of the NBS mass spectral library for each significant peak. The search results were then manually interpreted, tabulated, and checked by spectromatrists on the project staff.

Identification of Significant Peaks

Peaks were flagged as significant by INCOS "MAP" program, which uses a modified Biller-Biemann (2) algorithm for location of suspected compounds. This algorithm selects peaks based on the number of comaximizing masses at a particular scan number. For this work, "MAP" parameters were adjusted to prevent the flagging of very small peaks that have fewer than five comaximizing masses. Thus, some peaks were not flagged by the automated program for these screening analyses. Exhaustive manual identification of each chromatographic peak was not performed due to the very complex nature of the data.

Data Processing

The hardcopy obtained for each sample included an "enhanced" mass spectrum and results of the INCOS library search of the NBS mass spectral library. The enhanced spectrum is simply the spectrum of only those masses which comaximize at that particular scan number. The enhanced spectrum is chosen for the library search because it typically provides a mass spectrum which has most spurious ions and background removed by the enhancement process.

Manual Interpretation

Each mass spectrum and library search was evaluated by project staff and tentative identification was assigned as either a specific compound, a formula or compound group, or unknown. Specific compound assignments were given to those mass spectra which showed a very high degree of correspondence with the library (i.e., had high values for "FIT," "RFIT," and "PURITY") and have a discrete isomeric composition (e.g., phenol).

If the best library fits happened to be an indistinguishable group of isomers, a compound group or formula was assigned (e.g., xylene or C_4-alkylbenzene rather then e specific member of the group o-xylene or 1-ethyl-2,4-dimethylbenzene). Those mass spectra with poor library fits and features not recognizable by the analyst were labeled as unknown.

Because it is difficult to differentiate isomers, many of the identifications are a generic group. In addition, it must be recognized that other possible isomeric compounds may be present. For example, an identification of C_2-alkylbiphenyl [$C_2H_5C_6H_4$-C_6H_5 or $(CH_3)_2C_6H_3$-C_6H_5, etc.] may, in fact, be a methyl-diphenylmethane ($CH_3C_6H_4CH_2C_6H_5$) or a diphenylethane [$C_6H_5CH_2CH_2C_6H_5$ or $(C_6H_5)_2CCH_3$]. Best judgment, based on the starting materials, common combustion products and comparison to other products from the material were used to make identifications. Finally, since data enalysis was performed by several staff members, there may be some minor differences in the specific identifications from table to table based upon the experience and judgment of each analyst. Nevertheless, cross-checks of the data among the analysts indicated general agreement in the interpretation. Based on these cross-checks, any significant differences observed were resolved.

Semiquantitation of Thermal Degradation Products

The yields of the individual thermal decomposition products were determined by an external standard method. The area counts obtained for anthrecene from an injection of the standard solution served as the measure of the mass spectrometric response factor [RF (area counts/ng injected)]. At this point, it was assumed that all compounds have the same RF as anthracene, as it would be very expensive and difficult to obtain authentic standards for each product observed in these screening studies. For any given dey of pyrolysis or combustion experiments, the RF used to compute product yields was: the RF for the anthracene obtained that day if only one injection of the standard solution was made; the mean daily RF if more than one injection of the standard solution was made; or the RF from the previous day if no injection of the standard solution was made. Although the yield values are presented in the Appendix with two significant figures, the assumptions and variables associated with this particular experimental design may limit the accuracy of the yield maasurements.

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DATA QUALITY OBJECTIVE

Throughout the project, the goal of the experimental design is to provide a means to identify the major thermal decomposition products of selected utility materials. As this project is to be considered a "screening" of these materials, the semiquantitation of the products is included to provide a rough relative measure of the product yields for comparative purposes only.

Section 3

RESULTS AND DISCUSSION

The experimental work on this program was carried out in two distinct phases: (1) the screening of utility materials for the products of thermal degredation and (2) in-depth characterization of the thermal behavior of PVC.

The results from the screening experiments are grouped by material type, chlorine-containing materials, nitrogen-containing materials, and materials containing only C, H, and O and discussed in detail in the first part of Section 3. With the discussion of each material in Section 3 are included tables showing the 5 to 10 most abundant pyrolysis/combustion products for that material. In addition, for each material, the experimental results are presented in two formats in the appendices: detailed tables of product identifications and tables summarizing thermal dagradation product types. Detailed tables of identifications for all semiquantitative experiments can be found in Appendix A. The tables summarizing product types are presented in Appandix B. These tables list the number of compounds identified by chemical class and present a general overview of the information found in the detailed tables in Appendix A.

Some of the materials were tested twice during the screening phase of the program. For those materials, nitrile rubber, PVC, Kraft paper, dicyandiamida-treated Kraft papar, and mapla wood, the data presented in this report represents the tests performed during the latter, semiquantitative screening portion of this work.

The in-depth study of PVC during which PVC was subjected to different pyrolysis conditions using different pyrolyzers, including co-pyrolysis with other materials, is diacuased in detail in the second half of Section 3.

SCREENING OF SELECTED UTILITY MATERIALS

Chlorine-Containing Materials

Polyvinyl Chlorida (PVC). Pyrolysis of utility grade PVC at both 500° and 900°C producad abundant aromatic and alkylated aromatic degradation products (see Tables A-1 to A-4 and B-1 to B-4). In fact, the most abundant products included banzene, nephthalene, and anthracane for all of tha screening experiments (sae Table 3-1),

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which is in agreement with the literature (see reference 1 for a review). Although a fair number of chlorinated aromatic compounds such as chlorobenzenes and chlorotoluene are observed, the system background of chlorobenzenes may account for some of these. Since pure PVC has no oxygen atoms within its structure, it is of interest to note that dibenzofuran was observed in both of the pyrolysis experiments. Dibenzofuran was observed in the blank, however, at a significantly lower level than in the PVC tests. One possible explanation is that there are contaminants such as phthalate plasticizers or adsorbed oxygen on the surface of the utility grade PVC that could conceivably contribute oxygen to the products.

Table 3-1

MAJOR THERMAL DEGRADATION PRODUCTS OF PVC

	Rank by Abundance[a]			
	Pyrolysis		Combustion	
Product	500°C	900°C	500°C	900°C
Benzene	1[b]	1[b]	1[b]	1[b]
Toluene	4[b]			
Naphthalene	2[b]	2[b]	2[b]	2[b]
$C_{10}H_{10}$	5[b]	3[b]		
Anthracene	3	4	5	5
Biphenyl		5[b]		4[b]
Tetrachloroethylene			3	
Benzaldehyde			4[b]	3[b]

[a]Denotes rank of product by yield (1 = highest abundance).

[b]Denotes products also produced by pyrolysis of maple wood.

Combustion of the PVC conduit yielded much the same distribution of products as the pyrolysis test runs, with the exception that a few more oxygenated species were observed. Most notably, trichlorophenol and some aldehydes, such as benzaldehyde, are observed when PVC is thermally degraded in air, although not at nearly as high levels as the aromatics such as naphthalene, benzene, and anthracene.

The in-depth experiments on PVC yielded more insight into the mechanism and product distribution of PVC decomposition and are described later in this section.

Formel NF (Mixture of Tetrachloroethylene and Freons). The predominant product types observed for Formel NF by both pyrolysis and combustion (Tables A-5 to A-8 and B-5 to B-8) were small halogenated hydrocarbons consistent with the major components of Formel NF, such as chlorofluoroethanes (see Table 3-2).

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Table 3-2

MAJOR THERMAL DEGRADATION PRODUCTS OF FORMEL

Product	Rank by Abundance[a]			
	Pyrolysis		Combustion	
	500°C	900°C	500°C	900°C
Dichlorodifluoroethene	2[b]	2	4	2
Trichlorotrifluoroethanes	1[b]	3[b]	2	
Tetrechlorodifluoroethanes	3[b]	1[b]	1[b]	1[b]
Trichlorofluoromethanes	4[b]			
Fluorinated alkane		4	5	4
Pentachlorofluoroethane	5	5	3	3

[a]Denotes rank of product by yield (1 = highest abundance).

[b]Product designation represents the sum of all such products.

As might be expected for materials as volatile as this, the testing yields evidence that the majority of the meteriel is simply volatilizing upon heeting rether then thermelly decomposing. Furthermore, the short residence time of the semple in the pyrolysis zone in the filement pyrolyzer does not ellow further heeting of the meterial ebove 300°C. As it is possible in e reel fire that very volatile meteriels, such es Formel NF, may well beheve in this seme wey, yielding only volatilized components of the meteriel rether than thermel decomposition products, the greetest concern related to these materials mey be more closely releted to the materials themselves rather than their decomposition products.

Wecosol (Tetrechloroethylene). The Wecosol behaved very similarly to the Formel NF in the testing, yielding mostly small chlorineted molecules and tetrechloroethylene under ell four sets of conditions (Tebles A-9 to A-12 end B-9 to B-12). Chlorineted benzenes were observed (see Table 3-3), but ere elso present in the blenks at similar levels. It is cleer that most of the tetrechloroethylene passes through the system without any significent degree of thermal degradation when the present experimentel conditions ere used.

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Table 3-3

MAJOR THERMAL DEGRADATION PRODUCTS OF WECOSOL

Product	Rank by Abundance[a] Pyrolysis 500°C	Pyrolysis 900°C	Combustion 500°C	Combustion 900°C
Tetrahydromethylfuran	4			2
Tetrechloroethylene	2[c]	1[c]	1[c]	1[c]
Trichlorobenzenes	3[b,c]	2[c]	2[b]	3[b,c]
Alkenes	1[b,c]		5[b]	5[b,c]
Trichloroethene		3		
Tetrechlorobenzenes	5	5	3	4[c]
Pentachlorobenzene		4	4	

[a]Denotes rank of product by yield (1 = highest abundance).

[b]Denotes products also produced by pyrolysis of maple wood.

[c]Product designation represents the sum of all such products.

Electrochem FR-15 (Chlorobenzene Mix). Electrochem FR-15, which is mostly a mixture of tri- and tetrechlorobenzenes, like the Formel NF and Wecosol, is a liquid, but it has a much higher boiling point and might be expected to undergo some pyrolytic decomposition prior to voletilization. The expected products, chlorobenzenes, are observed in abundance (see Table 3-4), and may be both the rasult of thermal degredation and simple voletilization of the materiel. Other products of note include (Tables A-13 to A-16 and B-13 to B-16) some unchlorinated aromatics such as terphenyl and an oxygeneted species, tetrahydromethylfuren, which were observed in all but one of the experiments. It is possible that the tetrahydrofuren was a beckground component, although it wes not detected in the blanks.

The literature abounds (1) with reports of the formetion of chlorineted biphenyls (PCB), chlorineted dibenzofurens (PCDF), and chlorineted dibenzodioxins (PCDD) during the pyrolysis and combustion of chlorobenzenes. In most of these experiments, the duration of the thermal decomposition event is measured in several seconds through several hours. This may be contrested with the residence time in the present apparetus (filament pyrolyzer) which is on the order of 100 ms or less. Furthermore, any PCBs, PCDFs, and PCDDs would undoubtedly be formed at trace levels which would not be measurable under the present experimental conditions, due to the small sample sizes used.

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Table 3-4

MAJOR THERMAL DEGRADATION PRODUCTS OF ELECTROCHEM FR-15

Product	Rank by Abundance[a]			
	Pyrolysis		Combustion	
	500°C	900°C	500°C	900°C
Methylene chloride		5	5	
Tetrahydromethylfuran	4	3	4	
Dichlorobenzenes	5[c]		3[c]	4[c]
Trichlorobenzenes	1[c]	1[c]	1[c]	2[b,c]
Tetrachlorobenzenes	2[c]	2[c]	2[c]	1[b]
Pentachlorobenzene		4		3
Alkenes	3[b,c]			5[b]

[a]Denotes rank of product by yield (1 = highest abundance).

[b]Denotes products also produced by pyrolysis of maple wood.

[c]Product designation represents the sum of all such products.

Nitrogen-Containing Materials

Dicyandiamide-Treated Paper. The pyrolysis and combustion of Kraft paper treated with dicyandiamide (Tables A-17 to A-20 and B-17 to B-20) yields similar products to maple wood (see below) and are characteristic of cellulose-based materials (3). No evidence of the intact dicyandiamide or significant amounts of species containing nitrogen are observed, although some nitriles appear to be produced. The most abundant products (Table 3-5) include benzene and other aromatics, aldehydes, such as furancarboxaldehyde and tetradecanal, alkenoic acids such as tetradecanoic acid and some simple furans. Little difference is observed between the pyrolysis and combustion experiments, although a much larger number of alkylated aromatics are formed at 900°C in air than under the other conditions.

The dicyandiamide-treated crepe paper (Table 3-6) similarly does not yield any appreciable amounts of nitrogen-containing degradation products at 900°C in helium (see also Table A-21 and B-21). The crepe paper, however, does yield a much more abundant oxygenated product as is predicted for the papers (3). The reduced preponderance of polycyclic aromatic species for the crepe paper relative to the Kraft paper may be due to several factors including the type of wood used, the density of the paper structure, and the amount of additives and binders used in the preparation of the paper. The crepe paper was tested only at 900°C as directed by the EPRI project manager.

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Table 3-5

MAJOR THERMAL DECOMPOSITION PRODUCTS OF DICYANDIAMIDE-TREATED KRAFT PAPER

Product	Rank by Abundance[a]			
	Pyrolysis		Combustion	
	500°C	900°C	500°C	900°C
Benzene	5[b]		1[b]	
Tetradecanoic acid	4[b]			
Hexadecanoic acid		5[b]		
Alkenes	1[b,c]	1[b,c]	2[b,c]	1[b,c]
Toluene				2[b]
Styrene				3[b]
Indene		3[b]		
Biphenyl	3[b]	4[b]		5[b]
Octanal			3[b]	
Nonanal			4[b]	
Undecanal				
$C_{15}H_{15}S$	2[c]	2[c]	5	
Naphthalene				
Dibenzofuran				4[b]

[a]Denotes rank of product by yield (1 = highest abundance).

[b]Denotes products also produced by pyrolysis of maple wood.

[c]Product designation represents the sum of all such products.

Table 3-6

MAJOR THERMAL DECOMPOSITION PRODUCTS OF DICYANDIAMIDE-TREATED CREPE PAPER TESTED AT 900°C

Product	Rank by Abundance[a]
Methylfuran	1[b]
Methylbutenals	2[c]
Benzene	3[b]
Methylfurfural	4
Toluene	5[b]
Phenol	6[b]
Cresol	7[b]
Xylenol	8
Methylcyclopentadione	9
Ethylbenzene	10

[a]Denotes rank of product by yield (1 = highest abundance).

[b]Denotes products also produced by pyrolysis of maple wood.

[c]Product designation represents the sum of all such products.

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Nitrile Rubber. The nitrile rubber, like other polymers tested, yields a very large number of products under all test conditions (Tables A-22 to A-25 and B-22 to B-25). The dominant products (Table 3-7) for the nitrile rubber include alkenes, alkanes, phthalates, and benzene. Of further note, however, are the lesser products other than simple aliphatic or aromatic hydrocarbons. In this category are the nitriles, such as benzonitrile, some nitrogen heterocycles, such as dihydroindole, and a combined sulfur/nitrogen heterocycle, benzothiazole. The nitriles and nitrogen heterocycles are probably due to the thermal decomposition of the polymer, but the benzothiazole is probably an additive that has been simply volatilized from the polymer matrix.

Table 3-7

MAJOR THERMAL DEGRADATION PRODUCTS OF NITRILE RUBBER

	Rank by Abundance[a]			
	Pyrolysis		Combustion	
Product	500°C	900°C	500°C	900°C
Benzene	5[b]		4[b]	5[b]
Alkanes	2[b,c]	3[b,c]		
Unknowns	1[b,c]	2[b,c]	1[b,c]	2[b,c]
Phthalate esters	4[b,c]	1[c]	2[b,c]	1[b,c]
C_3-Alkenylbenzenes		5[b,c]		
Alkenes	3[b,c]	4[b,c]	3[b,c]	3[b,c]
Benzaldehydes			5[b]	5[b]

[a]Denotes rank of product by yield (1 = highest abundance).

[b]Denotes products also produced by pyrolysis of maple wood.

[c]Product designation represents the sum of all such products.

There is a pronounced increase in the production of all aromatic species (alkylated and otherwise) as the pyrolysis or combustion temperature is increased from 500° to 900°C. The results also indicate that the combustion conditions tend to favor formation of oxygenated species, most notably heterocyclic oxygen compounds, such as furans, and many compounds having the carbonyl function in the form of aldehydes and ketones. This fact indicates that there is a fair amount of combustion-like reactivity exhibited by the nitrile rubber under an atmosphere of air. However, these experiments reveal a much larger number of higher molecular weight products

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than those previously reported in the literature (1). This illustrates the variability among pyrolysis work carried out in different laboratories. Furthermore, the rapid rise in temperature and the short residence time in the heated zone in the MRI system both contribute to the relatively incomplete combustion of the materials. These incomplete combustion products are of considerable interest in this project, since they can occur in many fire regions and constitute the components of a fire residue which would be extracted and identified by other analytical techniques.

Nomex 411 (m-Phenylenediamine, Isophthalic Acid Polymer). The expected organic pyrolysis products for Nomex 411, such as m-phenylenediamine and 1,3-dicyanobenzene (1) were not observed in this work (Tables A-26 to A-29 and B-26 to A-29). In fact, very few products were observed, relative to some of the other polymeric materials such as nitrile rubber. The major products (Table 3-8) that were observed included, for the most part, some aromatic species and saturated or cyclic hydrocarbons in addition to some phthalate plasticizers. Notable in the Nomex 411 experiments were several major products not readily identifiable by the Incos library search or manual interpretation that appeer to contain nitrogen (due to odd-numbered masses of the molecular ion observed in the mass spectra). Additional extensive interpretive work would be required to obtain more positive identification of these species. The differences in the pyrolysis and combustion experiments for Nomex 411 are minor, indicating that the present experimental conditions ara not optimized for the oxidative thermal degradation of Nomex 411.

Table 3-8

MAJOR THERMAL OEGRADATION PRODUCTS OF NOMEX 411

	Rank by Abundance[a]			
	Pyrolysis		Combustion	
Product	500°C	900°C	500°C	900°C
Unknowns	1[b,c]	1[b,c]	1[b,c]	1[b,c]
$C_{14}H_2O_2$	3			
Alkanes	2[b,c]	2[b,c]		4[b,c]
Phthalate esters		3	3[b,c]	2[b]
Cycloalkanes	5		2[c]	
Dimethylethylcyclohexadienedione			4	3
Anthracene	4		5	5

[a]Denotes rank of product by yield (1 = highest abundance).

[b]Denotes products also produced by pyrolysis of maple wood.

[c]Product designation represents the sum of all such products.

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Creosote. Creosote has been thoroughly characterized in the past (1) and has been shown to contain a myriad of PAHs and heterocyclic PAHs containing sulfur, oxygen, and nitrogen. In the present study, both pyrolysis and combustion of creosote yielded similar product distributions (Tables A-30 to A-33 and B-30 to B-33) which are wholly consistent with the literature (1). Thus, the majority (Table 3-9) of the major products include aromatic compounds, such as naphthelene, anthracene, fluorene, and biphenyl, and alkylated aromatics, such as the methylnaphthalenes. Several of the heterocyclic PAHs such as dibenzofuran, dibenzothiophene, and ter bases such as quinoline are also evident. The fact that the products observed here have also been characterized as major components of creosote (1) is evidence for simple volatilization of the creosote under the present experimental conditions. Furthermore, the lack of significant differences in the combustion and pyrolysis experiments also suggests thet the products are not resulting from thermal decomposition, but are simply due to the volatilization of the starting material.

Table 3-9

MAJOR THERMAL DEGRADATION PRODUCTS OF CREOSOTE

Product	Rank by Abundance[a]			
	Pyrolysis		Combustion	
	500°C	900°C	500°C	900°C
Naphthalene	2[b]	1[b]	1	2[b]
$C_{11}H_{10}$s	1[b]	5[c]		3[b]
Biphenyl				6[c]
$C_{12}H_{10}$	5	4		5
C_2-Alkylnaphthalenes	3[b]	3[b]	2[b]	1[b]
Methylnaphthalene			5	
Acenaphthene	6		4	
Anthracene			3	
Unknowns	4[b,c]	2[b,c]	6[b,c]	4[b,c]

[a]Denotes rank of product by yield (1 = highest abundance).

[b]Product designation also produced by pyrolysis of maple wood.

[c]Denotes products also produced by pyrolysis of maple wood.

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Materials Containing Only C, H, and/or O

Maple Wood. Thermal degradation of maple wood under all four sets of experimental conditions yielded the expected products (see Tables A-34 to A-37 and B-34 to B-37) for a cellulose-based material. Namely, oxygenated species (methoxyphenol, methylfuran, and aldehydes) are formed, along with a wide variety of purely hydrocarbon species such as the alkylbenzenes. It is interesting to note, however, the most abundant product types (see Table 3-10) for maple wood under the present experimental conditions appear to be simply alkenes, alkanes, and benzene. A significant effect of pyrolysis temperature was observed, as at 500°C, few alkylated aromatics were formed, whereas at 900°C, a wide variety of alkylated aromatics such as alkylbenzenes, alkylbiphenyls, and alkylindenes are formed. When thermally decomposed under air in the combustion experiments, maple wood tends towards the formation of many more oxygenated species, most notably alkehydes such as benzeldehyde, furancarboxaldehyde, haptanal, or decanal. Furthermore, the fact that the list of products identified from the pyrolysis of maple wood is so large and composed of many organic compounds indicates again that the nature of the present experiment is that of incomplete thermal decomposition rather than exhaustive destruction.

Table 3-10

MAJOR THERMAL DEGRADATION PRODUCTS OF MAPLE WOOD

	Rank by Abundance[a]			
	Pyrolysis		Combustion	
Product	500°C	900°C	500°C	900°C
Tetradecanoic acid	5			
Hexedecanoic acid	4			
Alkenes	1[b]	2[b]	1[b]	1[b]
Benzene		3	3	3
Biphenyl		4		
Fluorene		5		
Alkanes	3[b]	1[b]	4	2[b]
Undecanal			5	
Phthalate esters	2[b]		2	
Benzaldehyde				4
Octanal				5

[a]Denotes renk of product by yield (1 = highest abundance).

[b]Product designation represents the sum of all such products.

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Kraft Paper. The products for the pyrolysis and combustion of Kraft paper (Tables A-38 to A-41 and B-38 to B-41) are very similar to those found for maple wood and the dicyandiamide-treated Kraft paper, and consistent with the literature (1). Low temperature, 500°C, experimants in both air and He produced large numbers of the axpected oxygenated species, such as furans, aldehydas, and phenols. At the higher temparatures, 900°C, the major products included aromatic and alkyl aromatic compounds to a much greater degree than the oxygenated species. Even in an atmosphere of air, the 900°C decomposition of Kraft paper yielded a greater number of aromatic species than oxygenated species which is the opposite of the results for maple wood. As the Kraft paper has a much lower density than the maple wood, it may be that the density plays a major role in the degradation processes of the cellulose-based materials. This observation may be worth further investigation.

As noted in Table 3-11, the major thermal degradation products of Kraft paper are dominated by unknown materials, alkenes, benzene, and phthalate esters. The phthalate esters are not expected, as they are typically found in plastics; however, it is possible that their presence is due to the handling and storage of the Kraft paper after manufacture.

Table 3-11

MAJOR THERMAL OEGRAOATION PROOUCTS OF KRAFT PAPER

	Rank by Abundance[a]			
	Pyrolysis		Combustion	
Product	500°C	900°C	500°C	900°C
Benzene	3[b]		2[b]	
Unknowns	1[b,c]	2[b,c]	1[b,c]	1[b,c]
Alkenes	2[b,c]	1[b,c]	4[b,c]	4[b,c]
Hexadecanoic acid	5[b]			
Phthalate asters	4[b,c]	3[b,c]	3[b,c]	2[b,c]
Toluene		5[b]		
Styrene		4[b]		
Biphenyl				3[b]
Benzaldehyde			5[b,c]	
Naphthalene				5[b]
Dibenzofuran				

[a]Oenotes rank of product by yield (1 = highest abundance).

[b]Oenotes products also produced by pyrolysis of maple wood.

[c]Product designation represents the sum of all such products.

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Rag Paper and Kraft Pressboard. Rag paper and Kraft pressboard, both cellulose-based materials, were tested during the very early screening phase of this project using only the 900°C pyrolysis conditions (see Tables A-42 to A-43 and B-42 to B-43). The most striking feature of the pyrograms for these materials is the similarity in the major products (see Tables 3-12 and 3-13). Both materials yield abundant methylfurans, benzene, C_6H_6O, and toluene upon pyrolysis, which suggests that they have very similar microstructures. It is also of note that nearly all of the major products found for these materials are also characteristic of maple wood and the Kraft paper. The rag paper and Kraft pressboard, however, do not yield an overwhelming number of alkenes, alkanes, or even phthalates. This fact may be related to the relative density of the materials more so than their structures.

Table 3-12

MAJOR PYROLYSIS PRODUCTS OF RAG PAPER

Product	Rank by Abundance[a]
Methylfurans	1[b,c]
Benzene	2[b]
C_6H_6O	3[c]
Toluene	4[b]
Furanylethanone	5
Unknown ester	6
Methylbutenal	7
Hydroxymethylcyclopentenone	8[b]
Cresol	9[b]
C_6H_8	10

[a]Denotes rank of product by yield (1 = highest abundance).

[b]Denotes products also produced by pyrolysis of maple wood.

[c]Product designation represents the sum of all such products.

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Table 3-13

MAJOR PYROLYSIS PRODUCTS OF KRAFT PRESSBOARD

Products	Rank by Abundance[a]
Methylfurans	1[b,c]
Benzene	2[b]
C_5H_8O	3[c]
Toluene	4[b]
Methylbutenals	5[c]
Phenol	6[b]
Methylfurfural	7
Methoxymethylbutane	8
Tetramethylcyclobutene	9
Ethylbenzenediol	10

[a]Denotes rank of product by yield (1 = highest abundance).

[b]Denotes products also produced by pyrolysis of maple wood.

[c]Product designation represents the sum of all such products.

Cross-Linked Polyethylene (CPE), 35-kV Cable Insulation. The major products (Table 3-14) for the pyrolysis of cross-linked polyethylene at 900°C included a large number of unsaturated hydrocarbons and a surprising number of alkylated aromatic species (Tables A-44 to A-47 and B-44 to B-47). This was not true at the lower pyrolysis temperature. Combustion of the CPE yielded quite different results, with the predominant product species being alkenes and aldehydes with a much greater proportion of alkane formation than in the pyrolysis experiments. It was predicted that CPE would yield pyrolysis products that are very similar to those from linear polyethylene (LPE) (1); however, this work shows a much lower tendency of CPE to produce the characteristic dienes, alkenes, and alkanes that are reported for LPE. Rather, the predominence of alkyl aromatic species in the high temperature pyrolysis experiment indicates that the cross-linking may provide a route to formation of aromatic compounds during thermal decomposition.

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Table 3-14

MAJOR THERMAL DEGRADATION PRODUCTS OF 35-kV CABLE CPE INSULATION

Product	Rank by Abundance[a]			
	Pyrolysis		Combustion	
	500°C	900°C	500°C	900°C
Alkenes	1[b,c]	1[b,c]	1[b,c]	2[b,c]
Hexadecanoic acid	3			
Alkenols		3[c]		
Alkanes	2[b,c]	2[b,c]		1[b]
Benzene			5[b]	
Nonanal			2[b]	5[b]
Decanal			4[b]	
Undecanal			3[b]	3[b]
Dodecanal				4[b]
Tetradecanoic acid	4[b]			
Pentadecanoic acid	5[b]			
Styrene		5[b]		
Diphenyl		4[b]		

[a]Denotes rank of product by yield (1 = highest abundance).

[b]Denotes products also produced by pyrolysis of maple wood.

[c]Product designation represents the sum of all such products.

Midel 7131 (Pentaerythrital Aliphatic and Aromatic Esters). Midel 7131 is a viscous liquid composed of a proprietary mixture of aliphatic and aromatic esters of pentaerythritol. As such, it is not surprising that the major identifiable products are esters and ketones of relatively long chain hydrocarbons (Table 3-15). For example, the major products for the 500°C pyrolysis test are methylheptanoate, tridecanone, and methylundecanone (Tables A-48 to A-50 and B-48 to B-50). Many other of the major components are not identified, but are likely to be similar in structure to those compounds listed above. Pyrolysis at the 900°C level does not change the identity or the amounts of products appreciably. Combustion of the Midel 7131 at 500°C produces some new products, namely smaller ketones, such as methylcyclopentenone and other oxygenated species such as phenol, acetic anhydride, and benzoic acid. From the literature review (1), it was predicted that Midel 7131 may produce such toxic products as PAHs and aldehydes. It is clear from this work that the major products are not PAHs or aldehydes, but alkyl ketones, esters, and some small aliphatic and aromatic carboxylic acids and anhydrides. However, as the literature is sparse for Midel 7131, it may be a good candidate for further characterization since it gives an array of interesting and unique thermal decomposition products.

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Table 3-15

MAJOR THERMAL DEGRADATION PRODUCTS OF MIDEL 7131

Product	Rank by Abundance[a] Pyrolysis 500°C	Pyrolysis 900°C	Combustion 500°C
Benzene	5	6[b]	6
Alkyl ketones		4[c]	3[c]
Tridecanone	4	3	5
Methylundecanones	3[c]		
C_3-Alkylbiphenyls	2[c]	5[c]	2[c]
Nonanones		2[c]	
Unknowns	1[b,c]	1[b,c]	1[b,c]
Acetic acid anhydride			4

[a]Denotes rank of product by yield (1 = highest abundance).

[b]Denotes products also produced by pyrolysis of maple wood.

[c]Product designation represents the sum of all such products.

Wemcol (Isopropylbiphenyl). Two types of Wemcol were subjected to testing in the project--new fluid and used fluid from a capacitor. As Wemcol is a relatively volatile fluid, the thermal testing revealed many products (Tables 3-16 and 3-17) that are clearly either major components or impurities of the bulk material that are simply volatilized under the present conditions. Thus, the majority of the alkylated biphenyls that were observed are probably not thermal decomposition products but components of the Wemcol. However, several aromatic species and alkylated benzenes are observed under all conditions that could be either decomposition products or actual components of Wemcol. The combustion experiments reveal a fair number of oxygenated species that are not observed in the pyrolysis experiments (see Tables A-51 to A-53 and B-51 to B-53). Several aldehydes such as nonanal and benzaldehyde as well as some ketones and phenols appear to be produced in relatively high yields in the combustion experiments. This indicates that despite the domination of simple volatilization of Wemcol in these tests, there is a fair amount of pyrolysis (or thermal decomposition) that occurs. However, for more extensive characterization of the thermal decomposition processes of Wemcol or other volatile materials, it may be necessary to use different or modified pyrolysis instrumentation.

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Table 3-16

MAJOR THERMAL DEGRADATION PRODUCTS OF USED WEMCOL

Product	Rank by Abundance[a] Pyrolysis 500°C	Pyrolysis 900°C	Combustion 500°C	Combustion 900°C
Benzene	3[b]		2[b]	2[b]
Biphenyl	4[b]		4[b]	
C_4-Alkylbiphenyls	1[c]		3[c]	
C_3-Alkenylbiphenyls	2[c]		1[c]	1[c]
Styrene	5	3[b]	5	3[b]
Indene		4[b]		
Naphthalene		5[b]		
$C_{15}H_{14}$[s]		2[c]		
$C_{18}H_{22}$[s]		1[c]		

[a]Denotes rank of product by yield (1 = highest abundance).

[b]Denotes products also produced by pyrolysis of maple wood.

[c]Product designation represents the sum of all such products.

Table 3-17

MAJOR THERMAL DEGRADATION PRODUCTS OF NEW WEMCOL

Product	Rank by Abundance[a] Pyrolysis 500°C	Combustion 500°C	Combustion 900°C
Benzene	4	4[b]	
C_3-Alkylbiphenyl			4
C_3-Alkenylbiphenyls	1[c]	1[c]	2[c]
C_4-Alkylbiphenyls	2[c]		
$C_{14}H_{10}$	3	3	
Biphenylylethenones		2[c]	1[c]
Biphenyl	5[b]	5[b]	3[b]
$C_{11}H_{10}$			5

[a]Denotes rank of product by yield (1 = highest abundance).

[b]Denotes products also produced by pyrolysis of maple wood.

[c]Product designation represents the sum of all such products.

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Comparison of the new versus the used Wemcol revealed only slight differences, with the used Wemcol having relatively higher levels of polycyclic aromatic hydrocarbons such as naphthalene and indene.

Edisol-III. Edisol III (C_3-alkylbiphenyls and phenylxylylathane) was tested at all four screening conditions. Regardless of conditions, the major products (Table 3-18) from the Edisol III appear to be largely either the starting material, which passed through the system unchanged (the alkylbiphenyls), or closely related direct decomposition products (C_3-alkylbenzenes). It is unclear from the data whether some compounds (e.g., the larger alkyl aromatics such as $C_{14}H_{14}$) are impurities in the Edisol III or reaction products. The products from this material do not differ markedly among those obtained by the four conditions. There are a few more oxidative products (see Tables A-54 to A-57 and B-54 to B-57) (aldehydes and ketones) in the combustion samples. Since Edisol III and Wemcol are liquids, it is not surprising that a substantial portion of these materials is simply vaporized in the experimental system rather than undergoing reaction.

Table 3-18

MAJOR THERMAL DEGRADATION PRODUCTS OF
EDISOL III (C_3-ALKYLBIPHENYLS AND PHENYLXYLYLETHANE)

	Rank by Abundance[a]			
	Pyrolysis		Combustion	
Product	500°C	900°C	500°C	900°C
$C_{15}H_{16}$[s]	1[b]	1[b]	1[b]	1[b]
$C_{14}H_{14}$	2[b]	5	3[b]	4
$C_{14}H_{22}$[s]	3[b]		2[b]	
Styrene	4[b]	3	5	3
Xylenes	5[b]			
$C_{16}H_{18}$[s]		2[b]		2[b]
Biphenyl		4		5
$C_{14}H_{12}$			4	

[a]Denotes rank of abundance by yield (1 = highest abundance).

[b]Product designation represents the sum of all such products.

Formex Wire Enamel. The Formex wire enamel was tested using the 900°C pyrolysis conditions during the early screening work on this project. The major products (Table 3-19) of alkylbenzenes are probably due to the petroleum-based solvent for

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the enamel. Other major products, such as phenol and the alkylphenol, may indicate a phenolic-type resin material. Most of the products (see Table A-58 and B-58) are early-eluting and very characteristic of a naphtha-based solvent. However, one nitrogen heterocycle was observed. A search of the patent literature indicates that many patents have been issued for wire- or cable-coating enamels under the Formex name, most of which have polyamide or polyimide components in the coating. Thus, the presence of the nitrogen-containing product may be explainable if the enamel is similar to those reported in the patent literature.

Table 3-19

MAJOR PYROLYSIS PRODUCTS OF FORMEX WIRE ENAMEL AT 900°C

Product	Rank by Abundance[a]
C_4-Alkylbenzenes	1[b,c]
Hexadecanoic acid	2[b]
C_3-Alkylbenzenes	3[b,c]
Phenol	4[b]
C_5-Alkylbenzenes	5[c]
Methyleneindene	6[b]
2-Methylpropyl ester	7
C_2-Alkylphenols	8[c]
Phenylcarbamate	9
Methyldihydroindene	10

[a]Denotes rank of product by yield (1 = highest abundance).

[b]Denotes products also produced by pyrolysis of maple wood.

[c]Product designation represents the sum of all such products.

Phenolic Resin-Containing Materials. Two Kraft phenolic laminates (Herkolite and Spauldite) were pyrolyzed at 900°C (Tables A-59 to A-60 and B-59 to B-60, respectively). The two materials gave remarkably similar chromatograms and also similar lists of identified compounds. Many of the oxygenated materials (cresols and alkylphenols, see Tables 3-20 and 3-21) may be attributed to either the paper component or the polymeric resin component. The presence of the nitrogen heterocycles was not expected. The phenolic resin is probably most like the Novolak resins which contain only C, H, and O as discussed under the bisphenol A epoxy resin section in

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the literature review (see page 6-2 of reference 1). Neither the structure nor the literature review of previous work indicates the presence of nitrogen heterocycles. It may be that these are attributable to additives or other materials present in the sample.

Table 3-20

MAJOR PYROLYSIS PRODUCTS OF HERKOLITE AT 900°C

Product	Rank by Abundance[a]
Cresols	1[b,c]
C_2-Alkylphenols	2[c]
Phenol	3[b]
C_3-Alkylphenols	4[c]
Toluene	5[b]
Ethylbenzene	6
Methylacridines	7[c]
Naphthalenamine	8
Vinylbutenal	9
Benzene	10[b]

[a]Denotes rank of product by yield (1 = highest abundance).

[b]Denotes products also produced by pyrolysis of maple wood.

[c]Product designation represents the sum of all such products.

Table 3-21

MAJOR PYROLYSIS PRODUCTS OF SPAULDITE AT 900°C

Product	Rank by Abundance[a]
C_2-Alkylphenols	1[b]
Cresols	2[c]
Toluene	3[b]
Ethylbenzene	4
C_3-Alkylphenols	5[c]
Methylfuranone	6
Phenol	7[b]
Benzene	8[b]
$C_{10}H_{12}$	9
$C_{10}H_9N$	10

[a]Denotes rank of product by yield (1 = highest abundance).

[b]Denotes products also produced by pyrolysis of maple wood.

[c]Product designation represents the sum of all such products.

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PYROLYSIS AND COMBUSTION PRODUCTS OF PVC

Background

Since the restriction of manufacture and commercial use of polychlorinated biphenyls (PCBs) in 1976, there has been considerable interest within the electrical utility industry regarding the acceptability of the alternative dielectric fluids and their thermal degradation products. In addition, the PCB issue has also sparked interest regarding the other types of materials presently used in utility devices, such as plastics, binders, paints, support materials, and electrical insulators, and their potential for production of undesirable species in the event of a fire. Of particular interest are chlorine-containing materials, which have been implicated as a source for the formation of polychlorinated dibenzo-p-dioxins and furans (PCDDs and PCDFs) during a fire. Materials in this category include PCBs, some of the alternate dielectric fluids such as tetrachloroethylene or trichlorobenzene mixtures, and polyvinyl chloride (PVC), which is used as a wire insulation.

PVC has been the subject of many studies designed to elucidate its thermal degradation processes for the purposes of polymer research, which have identified the primary products of PVC degradation to be HCl and benzene (4). As a result, various studies have been designed to investigate the role of PVC as a chlorine source for the formation of PCDDs, PCDFs, and their precursor molecules [polychlorophenols (CP), polychlorobenzenes (CB), and PCBs] in waste incineration and fires. These studies have ranged from simple laboratory pyrolysis experiments (5, 6, 7) to elaborate, full-scale incineration field studies (8, 9, 10).

In general, it has been shown that laboratory pyrolysis or combustion of PVC produces mostly benzene and other larger aromatic molecules with only traces of CPs or CBs. However, on a larger scale, the results vary considerably. One study involving a pilot-scale incinerator reported the formation of ppm levels of PCDDs and PCDFs from the combustion of PVC in air at 800°C (7). At the other extreme, in a study in which an excess of PVC was injected into the waste feed of a working municipal waste incinerator (9), it was found that there was no correlation of the amount of PVC in the waste feed with levels of chlorinated molecules in the stack gases or fly ash.

A utility fire, however, may be expected to proceed in a different fashion than incineration, as there are many metal surfaces and only a limited number of materials available to react with the PVC and its pyrolysates. Furthermore, the

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variebles important to the combustion of PVC, such as temperature, oxygen content of the surrounding environment, and residence time, are not constant or consistent in a utility fire.

In this study, the pyrolysis end combustion of PVC were investigated in detail with respect to the formation of toxic pyrolysates in two separate laboratory pyrolysis systems. Furthermore, as PVC is rarely used alone, the effects of added organic material or catelytic surfaces thet might be found with PVC in e utility device, on the thermel degradation of PVC, were investigated. For these experiments, the materials ethylene propylene rubber (EPR), iron (III), oxide (rust), and steel were chosen to be co-pyrolyzed with PVC, as they are commonly found in utility devices. From this work, it wes hoped that additional information regarding the potential of PVC to form undesirable pyrolysates in a utility fire is obtained.

Results

PVC. PVC was pyrolyzed at several temparatures and under atmospheres of helium and air using two fundamentally different pyrolyzers. The first, a filament pyrolyzer, is identical to the system used for tha bulk of the work carried out on this project and reported in the previous section. The second is a furnace pyrolyzer in which the sample is deposited within the hot zone of the pyrolyzer and flushed out with the pyrolysis gas onto the head of the GC column.

The major thermal degradation products of the PVC wire insulation as determined by EI-GC/MS with the filament pyrolyzer are summerized in Table 3-22 (see also Table 3-23 for a summary of the thermal degradation products PVC by compound type). In general, pyrolysis of PVC resulted in the formation of aromatic and alkylated aromatic species such as benzene, styrene, and nephthalene. Some oxygenated species, namely, hexadecanoic acid and phthalic acid or anhydride, are observed, but may be due to additives in the PVC or as a result of human handling prior to receipt at MRI. Combustion on the filament pyrolyzer at 900°C yields the same types of products with the addition of some chlorinated species (chlorobenzenes), some aliphatic species (alkanes and alkenes), and increased abundance of the oxygenated species, such as benzaldehyde and phthalates. The chlorobenzenes were observed in all experiments to some extent. However, the combustion experiments reveal a relative increase in the production of the chlorobenzenes with respect to the other products (see Table 3-23) which may indicate a catalytic effect due to the presence of oxygen.

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Table 3-22

PRODUCTS OF THE THERMAL DEGRADATION OF PVC USING THE FILAMENT PYROLYZER

Product	% Relative Abundance[a] Pyrolysis, 900°C	Combustion, 900°C
Benzene	28.9	9.9
Biphenyl	1.6	
$C_{11}H_{10}$		0.8
Oihydronaphthalene	2.9	
Fluorene	0.9	
Indene/C_3-alkynylbenzene	2.9	0.6
Naphthalene	7.1	2.1
C_2-Alkylbenzene	3.4	8.8
C_3-Alkenylbenzene	1.7	
Methylindene	3.7	
Methylnaphthalene	4.8	1.1
Styrene	5.8	
Toluene	9.8	4.2
Alkane		6.1
Alkene		5.3
Chlorobenzene		1.2
Dichlorobenzene		1.6
Pentechlorobenzene		1.2
Tetrachlorobenzene/$C_{12}H_{10}$		3.6
Trichlorobenzene		1.8
Benzaldehyde		2.0
Hexadecanoic acid	1.9	1.5
Phthalates		3.7
Phthelic acid/enhydride	8.1	19.0

[a]Percent relative abundance with respect to total observed products.

Table 3-23

MAJOR PYROLYSIS AND COMBUSTION PRODUCT CLASSIFICATIONS FOR PVC (FILAMENT PYROLYZER)

Material	Experiment Type[a]	% Relative Abundance by Product Type[b] A	B	C	D	E
PVC	PY900	74	-	-	10	17
PVC	CO900	28	11	9.4	26	25
PVC + EPR	PY900	46	22	1.3	0.6	30
PVC + EPR	CO900	28	20	5.3	28	20
PVC + Rust	PY900	44	8.8	1.5	19	26
PVC + Rust	CO900	28	13	5.5	53	0.7

[a]PY900 = 900°C pyrolysis and CO900 = 900°C combustion.

[b]A = nonhalogenated aromatic products; B = aliphatic products; C = chlorinated products; D = oxygenated products; and E = unidentified products.

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The pyrolysis and combustion products of PVC resulting from the use of the furnace pyrolyzer with EI-GC/MS are shown in Table 3-24 and tabulated by product type in Table 3-25. The products are dominated by PAHs such as benzene, naphthalene, toluene, and styrene. Combustion in the furnace pyrolyzer does not appear to appreciably change the product distribution (see Table 3-25) except that some of the minor PAH products observed in the pyrolysis experiment do not appear in the combustion test. It is of note that the experiments involving the furnace pyrolyzer do not appear to produce any oxygenated or chlorinated species. Since residence times in the furnace are longer than for the filement, it is feasible that any oxygeneted or chlorinated species formed as primary combustion products in the furnace are reduced by secondary thermal reaction to the highly aromatic species.

Table 3-24

PRODUCTS OF THE THERMAL DEGRADATION OF PVC USING THE FURNACE PYROLYZER

Product	% Relative Abundance[a] Pyrolysis, 900°C	Combustion, 900°C
Acenaphthene	0.1	
Anthracene/phenanthrene	5.1	4.9
Benzene	32.2	36.4
Biphenyl	1.8	
Biphenylene/acenaphthylene	3.1	4.3
$C_{10}H_{10}$	0.1	
$C_{12}H_{10}$	0.8	
$C_{13}H_{10}$	0.6	
$C_{18}H_{10}$	0.7	
Fluoranthene/pyrene	2.1	
Fluorene	1.9	
Naphthalene	16.0	23.0
Phenalene	0.2	
Phenylnaphthalene	0.6	
C_2-Alkenylnephthalene	0.2	
C_2-Alkylbenzene	1.2	
C_2-Alkylnaphthalene	0.2	
C_3-Alkenylbenzene	0.4	
C_3-Alkynylbenzene	3.5	3.9
C_4-Alkynylbenzene		2.3
Methylanthracene	0.1	
Methylfluorene	0.3	
Methylnaphthalene	4.1	2.8
Styrene	5.3	6.7
Toluene	10.6	8.8
C_4H_8	3.1	
C_5H_8	1.0	
Cycloalkane		0.5

[a]Percent relative abundance with respect to total observed products.

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Table 3-25

MAJOR PYROLYSIS AND COMBUSTION PRODUCT CLASSIFICATIONS
FOR PVC (FURNACE PYROLYZER, EI-MS DETECTION)

Material	Experiment Type[a]	% Relative Abundance by Product Type[b]				
		A	B	C	D	E
PVC	PY900	92	4.1	-	-	3.9
PVC	CO900	93	3.1	-	-	3.9
PVC + EPR	PY900	94	3.6	-	-	2.4
PVC + Steel	PY900	94	-	-	-	6.0
PVC + Steel	CO900	100	-	-	-	-

[a] PY900 = 900°C pyrolysis and CO900 = 900°C combustion.

[b] A = nonhalogenated aromatic products; B = aliphatic products; C = chlorinated products; O = oxygenated products; and E = unidentified products.

The thermal degradation products of PVC were also characterized by negative chemical ionization (NCI) mass spectrometry when the furnace pyrolyzer was used. NCI is accomplished by forcing ionization of the products by electron capture thereby forming negative ions. Thus, NCI is very responsive to molecules having electronegative groups, such as nitro groups, and halogens. Furthermore, NCI is very responsive to PAHs as the number of rings increases, and to other molecules that have either large electron capture cross sections or can easily form organic anions by proton abstraction. The major products of PVC pyrolysis as detected by NCI (see Tables 3-26 and 3-27) are exclusively PAHs, such as acenaphthene, pyrene, fluoranthene, and phthalates, such as dioctylphthalate. This finding differs with the EI-MS results due to the different relative sensitivities of NCI and EI with respect to the PAHs. Likewise, NCI detection of the products of PVC combustion are, for the most part, PAHs. However, combustion clearly results in the production of several chlorinated species, most notably penta- and hexachlorobenzene, some chlorinated naphthalenes, and some unidentified higher molecular weight chlorinated species. It is of interest to note that the unknown chlorinated species are not PCBs or PCODs/PCOFs.

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Table 3-26

PRODUCTS OF THE THERMAL DEGRADATION OF PVC USING THE FURNACE PYROLYZER AND DETECTION BY NCI-MS

Product	% Relative Abundance[a] Pyrolysis, 900°C	Combustion, 900°C
Acenaphthene	19.9	9.68
Anthracene/phenanthrene		0.37
$C_{13}H_{10}$	1.36	0.12
$C_{17}H_{12}$	1.55	0.69
$C_{14}H_{10}$	14.1	9.87
$C_{18}H_{12}$		0.36
$C_{20}H_{12}$		0.98
Naphthalene		0.2
Pyrene/fluoranthene	33.5	19.3
Fluorenone		1.16
Phthalate	31.5	17.5
$C_6H_4Cl_2$		0.56
Hexachlorobenzene		25.6
Hexachloronaphthalene		0.74
Pentachlorobenzene		8.07
Pentachloronaphthalene		0.58
Tetrachloronaphthalene		0.18
Unknown-3 chlorines		0.13
Unknown-4 chlorines		1.03
Unknown-5 chlorines		1.48

[a]Percent relative abundance with respect to total observed products.

Table 3-27

MAJOR PYROLYSIS AND COMBUSTION PRODUCT CLASSIFICATIONS FOR PVC (FURNACE PYROLYZER, NCI DETECTION)

Material	Experiment Type[a]	% Relative Abundance by Product Type[b] A	B	C	D	E
PVC	PY900	68	-	-	32	-
PVC	CO900	42	-	38	18	2.0
PVC + EPR	PY900	87	-	1.4	11	0.6
PVC + EPR	CO900	78	-	10	9.4	2.6

[a]PY900 = 900°C pyrolysis and CO900 = 900°C combustion.

[b]A = nonhalogenated aromatic products; B = aliphatic products; C = chlorinated products; O = oxyganated products; and E = unidentified products.

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PVC + EPR. Ethylene propylene rubber is used as a wire insulation material that can be found in near proximity to PVC-clad wire in utility devices. To test whether the pyrolysis or combustion of PVC in the presence of other organic materials can produce new products not produced by PVC alone, pieces of PVC and EPR were tested together. Using the filament pyrolyzer, the pyrolysis and combustion of the mixed PVC and EPR yielded products (see Table 3-28) that are very similar to those produced by each material alone. The EPR produces a large number of aliphatic materials along with some alkylated benzenes and some oxygenated species such as phthalates and alkanoic acids, which are probably due to additives and as a result of handling. No new products were formed by thermal degradation of the mixture of PVC and EPR, which indicates that the pyrolysis products of each do not react to any appreciable extent. Furthermore, the mixture produces a product distribution nearly identical to that produced by PVC alone (see Table 3-23).

Using the furnace pyrolyzer with EI-MS detection, the addition of EPR to the PVC thermal degradation experiment does not change the overall product distribution (see Table 3-25). The bulk of the products are simply nonhalogenated aromatic species, such as benzene, toluene, styrene, naphthalene, and larger PAHs. When NCI-MS detection is used (see Table 3-27), the same type of result is observed; that is, there is a distinct increase in the production of chlorinated species relative to other products in the combustion experiments when compared to the pyrolysis experiments, much like that observed for PVC alone. Again, no new thermal degradation products were observed for the experiments involving the PVC/EPR mixture.

PVC + Iron. Pieces of PVC wire insulation were also tested in the presence of iron-conteining materials that may be found in a utility device, as it has been demonstrated that benzene will react with inorganically bound chlorine to form polychlorinated aromatics (11). Since benzene and HCl are the major pyrolysis products of PVC, the presence of a catalytic surface on rusty iron or stainless steel may be an important factor in the formation of chlorinated species during fires. For these tests, PVC was thermally degraded in the presence of common rust, Fe_2O_3, in the filament experiments, and in the presence of stainless steel wool in the furnace experiments due to the physical restraints of each system.

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Teble 3-28

PRODUCTS OF THE THERMAL DEGRADATION OF PVC + EPR
USING THE FILAMENT PYROLYZER UNDER EI-MS CONDITIONS

Product	% Relative Abundance[a]			
	EPR		EPR + PVC	
	Pyrolysis 900°C	Combustion 900°C	Pyrolysis 900°C	Combustion 900°C
Anthracene/phenanthrene	0.3	0.3	0.7	
Benzene	7.0	5.2	8.1	14.1
Biphenyl			0.8	
$C_{10}H_{10}$	2.9	1.7	4.2	
$C_{11}H_{10}$	2.4	1.3	4.3	
C_9H_{10}		0.8	2.2	
C_9H_8			2.5	
Dihydroindene	0.9			
Fluorene			0.7	
Indene	2.2	1.4		
Nephthalene	2.0	3.0	3.4	3.9
$C_{12}H_{20}$			0.7	
C_2-Alkylbenzene	2.8	2.7	3.6	1.8
C_2-Alkylnaphthalene	0.5		1.4	
C_3-Alkenylbenzene	2.3			0.3
C_3-Alkylbenzene	1.2	1.9		0.5
Methylnaphthalene			3.9	
Styrene		6.0	5.2	2.7
Toluene	5.7	5.1	4.4	4.4
Alkene	22.9	8.9	14.1	9.1
Alkene	11.5	2.3	3.9	8.7
Cycloalkene		11.1	3.0	1.9
Cyclohexadiene	3.8			
Methylcyclopentane			1.1	
Chlorobenzene	0.5	1.4	0.7	0.8
Dichlorobenzene		2.1	0.3	
Hexachlorobenzene		1.1		
Pentechlorobenzene		1.1		
Tetrachlorobenzene/$C_{12}H_{10}$		1.3		1.6
Trichlorobenzene		2.0	0.3	2.9
Benzaldehyde		1.4		1.0
Benzoic acid				0.6
Benzothiazole		0.8	0.6	
Hexadecanoic acid	5.7		1.3	
Nonanoic acid	1.2			
Phthalates	5.9	4.1	0.9	9.9
Phthalic acid/anhydride	5.7	1.4	5.2	12.9

[a]Percent relative abundance with respect to total observed products.

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In the filament and EI-MS experiments (see Table 3-23), the PVC and rust mixture did not appear to react much differently than PVC alone. The mixture does appear to generate more aliphatic products (alkanes and alkenes) and a definite increase in the production of oxygenated species, such as phthalates and alkanoic acids. However, the product distribution was still dominated by the aromatic species (benzene, naphthalene, styrene, and toluene). The relative production of chlorinated species did not increase in the PVC + rust experiments, nor were any previously unseen chlorinated species observed.

Using the furnace pyrolyzer with a stainless steel wool plug located in the hot zone, EI-MS detected a product distribution nearly identical to that of PVC alone (see Table 3-25). From these results, it appears that under the conditions used in this work, that is, short residence times at very high temperatures, there is no appreciable change in the pyrolysis products of PVC in the presence of iron species.

Trace Products. Because of the public concern regarding chlorinated dibenzo-p-dioxins and dibenzofurans, those compounds were investigated as possible trace pyrolysis/combustion products of PVC during this work by examination of mass chromatograms of the molecular ions for selected PCDDs and PCDFs. Using this method, no evidence of PCDD or PCDF formation was found for any of the pyrolysis or combustion experiments described above. However, since this is an on-line system, the sample amounts of PVC were limited to approximately 100 µg, which requires that the PCDDs or PCDFs be formed at a level of at least a 10-ppm yield (0.001% yield) to be observable.

In those experiments in which chlorobenzenes were not observed as major pyrolysis or combustion products (i.e., > 0.1% relative abundance), mass chromatograms of the polychlorobenzene molecular ions were examined for evidence of the trace formation of CBs. The results revealed that the CBs are formed at some, albeit low, level in nearly every experiment that involves PVC. For the furnace experiments using EI-MS detection, only the monochlorobenzene was observed in this way and represented approximately a 10-ppm (or 0.001%) yield from the PVC. The filament pyrolyzer produced a much greater abundance of CBs which unfortunately were also observed in the system blanks. However, in those experiments involving the combustion of PVC, the CBs are enhanced relative to other products (see Table 3-23), which indicates that they may be formed by the thermal degradation of PVC, especially in the presence of oxygen (see above).

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The furnace experiments using NCI detection, unlike the EI-MS experiments, revealed production of penta- and hexachlorobenzene (see Table 3-26), but no other lower chlorinated benzenes. This result demonstrates the extreme sensitivity of NCI-MS for polychlorinated molecules, as the fact that hexachlorobenzene is not observed in the EI-MS work on the furnace pyrolyzer shows that it is probably produced at levels of 10 ppm or less.

Conclusions

From the experimental results presented above, it is shown that the major products of PVC pyrolysis or combustion are benzene, alkylated aromatics, and higher aromatics such as nephthalene. This result is consistent with the literature regarding the thermal degradation of PVC, in which PVC is proposed to degrade by dehydrohalogenation followed by intramolecular ring formation and bond scission. The HCl liberated by this process is not found to provide a readily accessible source of chlorine for production of chlorinated organic species, but may be responsible for the formation of low levels of chlorinated benzenes and naphthalenes. This, too, is in accordance with the literature, which asserts that the HCl liberated in the thermal degradation of PVC actually catalyzes further dehydrohalogenation of the PVC polymeric structure, resulting in formation of nonhalogenated aromatic products.

Combustion of the PVC was expected to produce some products that may have incorporated oxygen, but was found not to be the case. The only new product that provides evidence that some combustion did occur was benzaldehyde, which was only observed in low abundance in some of the tests. The actual results showed that the oxygen is more likely to facilitate the formation of more and larger aromatic species during the combustion of PVC and/or EPR and to enhance the formation of chlorobenzenes to a limited extent, possibly by acting as a catalytic agent.

Section 4

CONCLUSION

Twenty materials were tested during this study for their abilities to generate toxic or otherwise undesirable products upon thermal decomposition both in air and in the absence of air. Each material produced its own unique product distribution (see Section 3); however, there were some commonalities among the materials that are appropriate to note here. The most common product, which was observed for nearly all of the materials, was benzene. It is suspected that as a very stable molecule, benzene is simply produced as the materials decompose into the most stable products. Other common products include alkanes, alkenes, alkylbenzenes, phthalates, and alkanoic acids. Many of the materials, having only C, H, and O in their formulas, decompose into simple alkanes, alkanes, and stable alkylbenzenes. The phthalates and alkanoic acids were observed for nearly every sample and can be attributed to handling and/or additives, especially if the material is polymeric, such as nitrile rubber or PVC.

Of greatest concern to the utility industry would be those materials that produce copious amounts of products that are not found in the benchmark material, maple wood. Included in this category are the chlorine-containing materials (Formel, PVC, Wecosol, and Electrochem), and those materials containing heteroatoms other than C, H, and O (nitrile rubber, creosote, and Nomex). The chlorine-containing materials, while not observed to produce any PCDDs or PCDFs, do promote the production of chlorobenzenes and are therefore of concern as possible precursors to the production of low levels of PCDDs and PCDFs. The nitrile rubber, creosote, and the Nomex may represent potential concerns due to the production of many products unique to each material. The nitrile rubber, for example, generates many nitriles upon thermal degradation, which are not commonly attributed to the thermal degradation of many natural materials. The Nomex was a unique case, as it yielded many products that could be identified by the screening techniques used in this study and is therefore a candidate for more extensive study to elucidate its thermal degradation products. Creosote is of concern as it produces a large number of PAHs that have been of environmental concern for several years, but are also products of automobile exhaust, maple wood smoke, and most fires.

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A feature of this study and the literature review (1) of particular interest is that there is a variance among the pyrolysis results from various laboratories. It is clear, therefore, that the reader must take care in the use of the results presented here and in the literature, as it is difficult to generate reproducible pyrolytic data across different laboratories. Factors that affect the reproducibility of this type of work include the heating rate, the sample amount, and the residence time--all variables difficult to reproduce from lab to lab. Furthermore, as this work was designed to model the processes that may be expected to occur in a fire, it is not a complete representation of a fire and, in that respect, may not accurately portray the processes in an actual utility fire.

Section 5

QUALITY ASSURANCE

Quality assurance at Midwest Research Institute is an integral part of the total project. QA activities ensure thet the reported data ere of known quality. This quality is obtained by the compliance of each phase of a project to specific protocols and standerd operating procedures and to MRI QA policies and program QA objectives. For a qualitative research project, the basic QA objectives are to review the procedures, raw data, and reports to determine if any systematic error exists that would affect the stated data quelity objectives.

The Quality Assurance Coordinator for this project, Jack Balsinger, has reviewed tha report and has randomly checked the raw data generated for this report.

Section 6

RECOMMENDATIONS

One limitation of the Py-GC/MS system used in this study during the screening of the utility materials that beceme apparent as the work progressed was that the Pyroprobe could not retain the volatile materials long enough to induca any significant amounts of pyrolysis. Although a Py-GC/MS system better suited for the study of liquids was availeble towerds the end of the study and wes used for a few of the PVC experiments, it was not aveilable for the screening experiments that make up the bulk of the work reported here. It is therefore recommended that the liquid materials screened in this study (Formex wire enamel, Wemcol, Edisol, Formel, Wecosol, Midel, creosote, and Electrochem) be examined by the use of a Py-GC/MS system which includes a furnace pyrolyzer such as that used in the latter part of this program.

As any one type of pyrolyzer cannot possibly rapresent accurately the processes that might occur in an actual utility fire, it is racommended by MRI that future studies include thermal degradation experiments carried out with a wide variety of apparatuses, such as filament and furnace pyrolyzers, and long residence time devices such as sealed-tube reactors. In this way, saveral different conditions that may exist in a fire may be represented, which should provide more accurate information to utility planners concerned with the performance of various materials during thermal accidents.

The chlorine-containing materials tested in this program were shown to not produce PCDDs and PCDFs under the conditions employed in this laboratory. However, the fact that these materials contain chlorine makes them suspect as starting materials for the production of some of the more toxic chlorinated species such as PCBs, PCDDs, and PCDFs. Tharefore, it is recommended that exhaustive literature searching and experimental testing accompany the selection of any utility material that incorporates chlorine in its structure, as it has been shown that various chlorinated materials (e.g., PCBs) do indeed produce PCDDs and PCDFs upon thermal decomposition.

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Section 7

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Appendix A

COMPLETE PROOUCT IOENTIFICATION TABLES FOR PYROLYSIS AND COMBUSTION DF UTILITY MATERIALS

Appendix A contains the complete tabular listings of the thermal degradation products for the utility materials screened during tha project. Those materials tested under the samiquantitative conditions have product yields relative to the amount of material tested shown. Otherwise, product abundances are indicated by their chromatographic peak areas.

Tabla A-1

PVC CONDUIT, 500°C PYROLYSIS[a]

Tentative Identification	Scan	RT (min)	Area	Yield[b] (µg/g)
Benzene	76	2:09	275198	3500
Toluene	118	3:21	84351	1100
Unknown	135	3:49	8655	110
Tetrachloroethene	143	4:03	27423	350
Siloxane	148	4:12	47487	610
Chlorobenzene	167	4:44	17727	230
C_2-Alkylbenzene	178	5:03	7759	100
Styrene	199	5:38	17183	220
Dichloropropene	219	6:12	9743	120
C_3-Alkenylbenzene	240	6:48	3211	41
Benzaldehyde	252	7:08	6615	85
Unknown	261	7:24	14927	190
Phenol	266	7:32	11231	140
Siloxane	274	7:46	90879	1200
Dichlorobenzene	284	8:03	8783	110
Chlorotoluene	289	8:11	18015	230
Unknown	298	8:27	19071	240
Indene	312	8:50	41855	540
Siloxane	379	10:44	81663	1000
$C_{10}H_{10}$	393	11:08	79359	1000
Naphthalene	407	11:32	141567	1800
Trichlorobenzene	424	12:01	19455	250
$C_{11}H_{10}$	473	13:24	17855	230
Siloxane	481	13:38	67199	860
Tetrachlorobenzene	492	13:56	10159	130
Unknown	507	14:22	9455	120
Biphenyl	519	14:42	75135	960
Unknown	524	14:51	3771	48
1,1'-Methylenebisbenzene	545	15:26	12207	160
Unknown	558	15:49	10687	140
Unknown	562	15:55	11103	140
Cycloalkane	567	16:04	10143	130
Siloxane	569	16:07	23263	300
Alkane	571	16:11	23071	300
Unknown	574	16:16	4655	60
Methylbiphenyl	576	16:19	3479	45
Dibenzofuran	590	16:43	15055	190
Pentachlorobenzene	592	16:46	19455	250
Fluorene	623	17:39	29407	380
Anthracene	715	20:15	85759	1100
Siloxane	745	21:06	45055	580
Terphenyl	756	21:25	3687	47
Phthalate ester	778	22:03	16831	220
Alkane	788	22:20	5343	69
Phenylnaphthalene	792	22:26	13119	170
Siloxane	800	22:40	34815	450

(continued)

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Table A-1 (concluded)

Tentative Identification	Scan	RT (min)	Area	Yield[b] (µg/g)
$C_{16}H_{14}$	816	23:07	6663	86
Pyrene	831	23:33	25919	330
Fluoranthene	853	24:10	22879	290
Siloxane	862	24:25	21279	270
Cycloalkane	1057	29:57	58175	750

[a]Amount pyrolyzed = 22 µg.

[b]Yield is computed with respect to the mass of the sample pyrolyzed. Product amounts are determined by comparison of their areas with that of an external anthracene standard, assuming relativa rasponses of one. Because of the assumptions implicit in the yield computations, the yield values are only within a factor of five. No internal standard methods or use of authentic standards were used to quantitate tha products in this study.

Table A-2

PVC CONDUIT, 900°C PYROLYSIS[a]

Tentative Identification	Scan	RT (min)	Area	Yield[b] (µg/g)
Benzene	73	2:04	166911	630
Toluene	117	3:19	47935	180
Tetrachloroethene	143	4:03	18271	69
Siloxane	149	4:13	36095	140
Chlorobenzene	167	4:44	11903	45
Styrene	198	5:37	12079	46
Chloroheptane	247	7:00	12015	45
Benzaldehyde	250	7:05	5655	21
Unknown	254	7:12	9903	37
Siloxane	271	7:41	89087	340
Unknown	286	8:06	8383	32
Chlorotoluene	288	8:10	9295	35
Unknown	296	8:23	8607	32
Indene	311	8:49	29855	110
Siloxane	378	10:43	74623	280
$C_{10}H_{10}$	392	11:06	67967	260
Naphthalene	406	11:30	128511	480
Trichlorobenzene	423	11:59	12591	47
$C_{11}H_{10}$	472	13:22	15215	57
Siloxane	481	13:38	57663	220
Unknown	498	14:07	6407	24
Unknown	509	14:25	5279	20
Biphenyl	518	14:41	59135	220
1,1'-Methylenebisbenzene	544	15:25	10831	41
Unknown	561	15:54	8927	32
Unknown	570	16:09	17983	68
Unknown	574	16:16	5103	19
Unknown	581	16:28	7551	28
Dibenzofuran	589	16:41	11615	44
Pentachlorobenzene	591	16:45	16959	64
Fluorene	622	17:37	30559	120
$C_{13}H_{12}$	630	17:51	8655	33
1,2-Diphenylethene	677	19:11	14047	53
Unknown	702	19:53	17823	67
Anthracene	714	20:14	65023	240
Siloxane	745	21:06	39231	150
Siloxane	780	22:06	2975	11
Unknown	786	22:16	9583	36
$C_{14}H_{12}$	791	22:25	8119	30
Unknown	799	22:38	32063	120
Pyrene	831	23:33	18399	69
Fluoranthene	852	24:08	13743	52
Siloxane	862	24:25	14687	55
$C_{17}H_{12}$	887	25:08	5495	21

(continued)

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Table A-2 (concluded)

Tentative Identification	Scan	RT (min)	Area	Yield[b] (µg/g)
Unknown	988	28:00	4183	16
Unknown	1017	28:49	1267	408
Unknown	1056	29:55	2087	709

[a]Amount pyrolyzed = 75 µg.

[b]Yield is computed with respect to the mass of the sample pyrolyzed. Product amounts are determined by comparison of their areas with that of an external anthracene standard, assuming relative responses of one. Because of the assumptions implicit in the yield computations, the yield values are only within a factor of five. No internal standard methods or use of authentic standards were used to quantitate the products in this study.

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Table A-3

PVC CONDUIT, 500°C COMBUSTION[a]

Tentative Identification	Scan	RT (min)	Area	Yield[b] (µg/g)
Benzene	88	2:30	208383	750
Unknown	134	3:48	7631	28
Unknown	144	4:05	11775	43
Cycloalkane	149	4:13	3179	12
Tetrachloroethene	151	4:17	75007	270
Siloxane	155	4:23	80767	290
Chlorobenzene	173	4:54	38399	140
C_2-Alkylbenzene	183	5:11	6879	25
Styrene	203	5:45	8591	31
Unknown	209	5:55	6927	25
Unknown	250	7:05	24223	88
Benzaldehyde	254	7:12	72703	260
Unknown	267	7:34	14095	51
Siloxane	274	7:46	59839	220
Benzofuran	279	7:54	3859	14
Unknown	281	7:58	16863	61
Dichlorobenzene	285	8:04	17503	63
Chlorotoluene	290	8:13	19583	71
C_9H_8	313	8:52	27839	100
Unknown	349	9:53	23871	86
Siloxane	379	10:44	46719	170
$C_{10}H_{10}$	393	11:08	32639	120
Naphthalene	407	11:32	132863	480
Trichlorobenzene	423	11:59	24287	88
3-Phenyl-2-propenal	456	12:55	19327	70
C_9H_8O	464	13:09	13295	48
Siloxane	481	13:38	40703	150
Tetrachlorobenzene	491	13:55	14607	53
Unknown	497	14:05	6679	24
Trichlorophenol	503	14:15	40831	150
Unknown	506	14:20	11775	43
Biphenyl	517	14:39	35775	130
Unknown	526	14:54	19967	72
$C_{13}H_{12}$	544	15:25	14271	52
Benzopyranone	549	15:33	3011	11
Unknown	560	15:52	12575	46
Siloxane	567	16:04	16271	59
Alkane	569	16:07	23007	83
Unknown	572	16:12	5991	22
Naphthalenecarboxaldehyde	582	16:29	10367	38
Pentachlorobenzene	590	16:43	37375	140
Fluorene	621	17:36	46719	170
Hexachlorobenzene	682	19:19	47743	170
Anthracene	713	20:12	61631	220
Siloxane	743	21:03	28735	100

(continued)

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Table A-3 (concluded)

Tentative Identification	Scan	RT (min)	Area	Yield[b] (µg/g)
$C_{18}H_{12}$	790	22:23	7055	26
Unknown	798	22:37	13583	49
Pyrene	829	23:29	16047	58
Fluoranthene	851	24:07	10975	40

[a]Amount pyrolyzed = 78 µg.

[b]Yield is computed with respect to the mass of the sample pyrolyzed. Product amounts are determined by comparison of their areas with that of an external anthracene standard, assuming relative responses of one. Because of the assumptions implicit in the yield computations, the yield values are only within a factor of five. No internal standard methods or use of authentic standards were used to quantitate the products in this study.

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Table A-4

PVC CONDUIT, 900°C COMBUSTION[a]

Tentative Identification	Scan	RT (min)	Area	Yield[b] (µg/g)
Benzene	79	2:14	223743	620
Toluene	143	4:03	25919	72
Tetrachloroethene	181	5:08	43263	120
Siloxane	194	5:30	36543	100
Chlorobenzene	217	6:09	27743	78
Unknown	227	6:26	5000	14
Styrene	259	7:20	12783	36
Unknown	270	7:39	13647	38
Benzaldehyde	324	9:11	107135	300
Siloxane	353	10:00	77695	220
Indene	392	11:06	36031	100
Unknown	433	12:16	54079	150
Siloxane	464	13:09	54207	150
Siloxane	465	13:10	53183	150
$C_{10}H_{10}$	467	13:14	4399	12
$C_{10}H_{10}$	477	13:31	31167	87
Trichlorobenzene	485	13:44	15567	44
Naphthalene	492	13:56	141823	400
Unknown	499	14:08	30239	84
Trichlorobenzene	509	14:25	25343	71
3-Phenyl-2-propenal	543	15:23	21471	60
Unknown	552	15:38	9295	26
Unknown	560	15:52	54911	150
Siloxane	568	16:06	47551	130
Phthalic acid	572	16:12	34879	98
Tetrachlorobenzene	578	16:23	7343	20
Trichlorophenol	590	16:43	32895	92
Biphenyl	605	17:08	74495	210
Unknown	644	18:15	18367	51
Unknown	663	18:47	29247	82
Pentachlorobenzene	676	19:11	20799	59
Fluorene	705	20:04	58175	160
Benzophenone	723	20:36	32831	92
Alkadiene	757	21:27	28507	80
Hexachlorobenzene	769	21:47	23551	66
Fluorenone	780	22:06	26335	74
Unknown	785	22:14	14735	41
Tetrahydrophenanthrene	789	22:21	13151	37
Anthracene	800	22:40	67711	190
Siloxane	830	23:31	28831	81
Unknown	836	23:41	12127	39
Cycloalkane	871	24:41	10351	29
Unknown	885	25:04	18207	51
Pyrene	917	25:59	10671	30

(continued)

MONS 217615

Table A-4 (concluded)

Tentative Identification	Scan	RT (min)	Area	Yield[b] (µg/g)
Siloxane	946	26:48	11423	32
Alkane	982	27:49	13279	37
Alkane	1015	28:45	4919	14

[a]Amount pyrolyzed = 100 µg.

[b]Yield is computed with respect to the mass of the sample pyrolyzed. Product amounts are determined by comparison of their areas with that of an external anthracene standard, assuming relative responses of one. Because of the assumptions implicit in the yield computations, the yield values are only within a factor of five. No internal standard methods or use of authentic standards were used to quantitate the products in this study.

Table A-5

FORMEL NF (MIXTURE OF PERCHLOROETHYLENE AND FREONS)[a], 500°C PYROLYSIS[b]

Tentative Identification	Scan	RT (min)	Area	Yield[c] (µg/g)
Dichlorodifluoroethene	51	1:27	262143	170
Trichlorotrifluoroethane	54	1:32	255743	160
Trichlorotrifluoroethane	59	1:40	288767	180
Methyltetrahydrofuran	80	2:16	50175	32
Tetrachlorodifluoroethane[d]	114	3:14	140031	88
Tetrachlorodifluoroethane[d]	135	3:49	82303	52
Trichlorofluoromethane	148	4:12	201471	130
Tetrachloroethylene	205	5:48	74495	47
Unknown	270	7:39	2603	1.6
Trichlorobutene	277	7:51	21247	13
Pentachlorofluoroethane	280	7:56	44031	28
Chlorinated unknown	327	9:16	7983	5.0
Chlorinated unknown	336	9:31	18207	11
Siloxane	350	9:55	9743	6.1
Dichlorobenzene	381	10:48	6127	3.9
Hexachloroethane	408	11:34	11455	7.2
Unknown	424	12:01	5727	3.6
Siloxane	452	12:48	18847	12
Cycloheptane	467	13:14	5455	3.4
Unknown	474	13:26	19007	12
Chlorinated unknown	488	13:50	58815	37
Chlorinated unknown	523	14:49	10655	6.7
Chlorinated unknown	527	14:56	7751	4.9
Unknown	545	15:26	5783	3.6
Siloxane	553	15:40	19199	12
Unknown	555	15:43	5671	3.6
Trichloro-C_2-alkenylbenzene	561	15:54	4743	3.0
Unknown	579	16:24	4759	3.0
Biphenyl	591	16:45	10575	6.6
Alkene	642	18:11	4987	3.1
Chlorinated unknown	667	18:54	5095	3.2
Chlorinated unknown	681	19:19	3047	1.9
Alkane	694	19:40	4895	3.1
C_3-Alkylbiphenyl	715	20:15	7879	5.0
Alkane	740	20:58	4919	3.1
Siloxane	779	22:04	23167	15

(continued)

MONS 217617

Table A-5 (concluded)

Tentative Identification	Scan	RT (min)	Area	Yield[c] (µg/g)
Alkene	781	22:08	3795	2.4
Siloxane	822	23:17	11247	7.1
Unknown	876	24:49	1753	1.1

[a]Composition from J. V. Zbozinek, J. R. Marsh, D. Guth, and A. Bohrnarud (SCS Engineers, Inc.). State-of-the-Art Review of Combustion and Pyrolysis By-Products of PCB Substitutes. Palo Alto, CA: Electric Power Research Institute, March 1986. EPRI EL-4503.

[b]Amount pyrolyzed = 810 µg.

[c]Yield is computed with respect to the mass of the sample pyrolyzed. Product amounts are determined by comparison of their areas with that of an external anthracene standard, assuming relative responses of one. Because of the assumptions implicit in the yield computations, the yield values are only within a factor of five. No internal standard methods or use of authentic standards were used to quantitate the products in this study.

[d]Major component of Formel, overloaded peak. Quantitation unreliable.

MONS 217618

Table A-6

FORMEL NF (MIXTURE OF PERCHLOROETHYLENE AND FREONS)[a], 900°C PYROLYSIS[b]

Tentative Identification	Scan	RT (min)	Area	Yield[c] (µg/g)
Dichlorodifluoroethene } Trichlorotrifluoroethane [d]	51	1:27	217855	140
Tetrachlorodifluoroethane[d]	95	2:41	169471	110
Tetrachlorodifluoroethane[d]	126	3:34	250879	160
Tetrachloroethylene[d]	180	5:06	59519	37
Fluorinated alkane	233	6:36	37119	23
Chlorobenzene	239	6:46	4311	2.7
Trichloromethylpropene	258	7:19	5311	3.3
Pentachlorofluoroethane	261	7:24	15823	9.9
Benzaldehyde	318	9:01	2407	1.5
Chlorinated unknown	326	9:14	2811	1.8
Siloxane	344	9:45	10159	6.4
Chlorinated unknown	358	10:09	1467	0.9
Dimethylcyclopentane	369	10:27	2539	1.6
Dichlorobenzene	376	10:39	3743	2.3
Hexachloroethane	405	11:28	10911	6.8
Cycloalkane	414	11:44	4455	2.8
Siloxane	455	12:53	17951	11
Cycloalkane	480	13:36	4703	2.9
Chlorinated unknown	490	13:53	7479	4.7
Trichlorobenzene	499	14:08	3115	2.0
Alkane	544	15:25	3883	2.4
Unknown	549	15:33	1487	0.9
Siloxane	557	15:47	16767	11
Unknown	593	16:48	8287	5.2
Unknown	644	18:15	4463	2.8
Alkane	696	19:43	6279	3.9
C_3-Alkylbiphenyl	717	20:19	4103	2.6
C_3-Alkylbiphenyl	732	20:44	3339	2.1
Alkane	742	21:01	4959	3.1
Siloxane	781	22:08	19763	12
Siloxane	824	23:21	7503	4.7

(continued)

MONS 217619

Table A-6 (concluded)

Tentative Identification	Scan	RT (min)	Area	Yield[c] (µg/g)
Unknown	864	24:29	1159	0.7
Unknown	904	25:37	1181	0.7
Unknown	975	27:37	829	0.5

[a]Composition from J. V. Zbozinek, J. R. Marsh, D. Guth, and A. Bohrnerud (SCS Engineers, Inc.). State-of-the-Art Review of Combustion and Pyrolysis By-Products of PCB Substitutes. Palo Alto, CA: Electric Power Research Institute, March 1986. EPRI EL-4503.

[b]Amount pyrolyzed = 810 µg.

[c]Yield is computed with respect to the mass of the sample pyrolyzed. Product amounts are determined by comparison of their areas with that of an external anthracene standerd, assuming reletive responses of one. Because of the assumptions implicit in the yield computations, the yield values are only within a facto. of five. No internal standard methods or use of authentic standards were usad to quantitate the products in this study.

[d]Major component of Formel, overloaded peak. Quantitation unreliable.

MONS 217620

Table A-7

FORMEL NF (MIXTURE OF PERCHLOROETHYLENE AND FREONS)[a], 500°C COMBUSTION[b]

Tentative Identification	Scan	RT (min)	Area	Yield[c] (µg/g)
Dichlorodifluoroethene	51	1:27	118783	75
Trichlorotrifluoroethane	53	1:30	296959	190
Tetrachlorodifluoroethane[d]	110	3:07	360959	230
Unknown	124	3:31	46271	29
Tetrachlorodifluoroethane[d]	145	4:06	335359	210
Tetrachloroethylene[d]	204	5:47	98687	62
Fluorinated alkane	251	7:07	42623	27
Chlorobenzene	256	7:15	19455	12
Pentachlorofluoroethane	279	7:54	151295	95
Benzaldehyde	333	9:26	10191	6.4
Siloxane	357	10:07	17951	11
Dichlorobenzene	367	10:24	2871	1.8
Dichlorobenzene	388	11:00	5599	3.5
Hexachloroethane	417	11:49	51967	33
Octanol	425	12:02	3255	2.0
Unknown	434	12:18	4423	2.8
Siloxane	464	13:09	13423	8.4
Trichlorobenzene	485	13:44	4615	2.9
Alkane	498	14:07	3787	2.4
Chlorinated unknown	503	14:15	9455	5.9
Trichlorobenzene	508	14:24	9375	5.9
Unknown	543	15:23	899	0.6
Alkene	548	15:32	1343	0.8
Alkane	553	15:40	2659	1.7
Unknown	557	15:47	1771	1.1
Siloxane	566	16:02	11391	7.2
Tetrachlorobenzene	577	16:21	6071	3.8
Tetrachlorobenzene	605	17:08	11439	7.2
Unknown	646	18:18	1781	1.1
Siloxane	657	18:37	3643	2.3
Pentachlorobenzene	680	19:16	14239	9.0
Alkane	706	20:00	2955	1.9
Unknown	713	20:12	1747	1.1
Hexachlorobenzene	770	21:49	8239	5.2

(continued)

MONS 217621

Table A-7 (concluded)

Tentative Identification	Scan	RT (min)	Area	Yield[c] (µg/g)
Siloxane	789	22:21	27455	17
Siloxane	831	23:33	11887	7.5
Unknown	884	25:03	2183	1.4

[a]Composition from J. V. Zbozinek, J. R. Marsh, O. Guth, and A. Bohrnerud (SCS Engineers, Inc.). State-of-the-Art Review of Combustion and Pyrolysis By-Products of PCB Substitutes. Palo Alto, CA: Electric Power Research Institute, March 1986. EPRI EL-4503.

[b]Amount pyrolyzed = 810 µg.

[c]Yield is computed with respect to the mass of the sample pyrolyzed. Product amounts are determined by comparison of their areas with that of an external anthracene standard, assuming relative responses of one. Because of the assumptions implicit in the yield computations, the yield values are only within a factor of five. No internal standard methods or use of authentic standards were used to quantitate the products in this study.

[d]Major component of Formel, overloaded peak. Quantitation unreliable.

MONS 217622

Table A-8

FORMEL NF (MIXTURE OF PERCHLOROETHYLENE AND FREONS)[a], 900°C COMBUSTION[b]

Tentative Identification	Scan	RT (min)	Area	Yield[c] (µg/g)
Dichlorodifluoroethene	50	1:25	175359	110
Tetrachlorodifluoroethane[d]	114	3:14	66175	42
Tetrachlorodifluoroethane[d]	123	3:29	320511	200
Tetrachloroethylene[d]	181	5:08	39807	25
Fluorineted alkane	224	6:21	5063	3.2
Chlorobenzene	227	6:26	19775	12
Chlorinated unknown	246	6:58	3003	1.9
Pentechlorofluoroethane	250	7:05	60351	38
Unknown	252	7:08	3867	2.4
Benzaldehyde	310	8:47	11183	7.0
Benzonitrile Phenol	329	9:19	6479	4.1
Siloxane	337	9:33	10015	6.3
Unknown	342	9:41	5423	3.4
Dichlorobenzene	347	9:50	5151	3.2
Dichlorobenzene	352	9:58	3055	1.9
Dichlorobenzene	370	10:29	8575	5.4
C_3-Alkylbenzene	395	11:11	4807	3.0
Hexechloroethane	401	11:22	16095	10
Cycloalkane	411	11:39	4287	2.7
Alkene	420	11:54	7775	4.9
Unknown	430	12:11	1369	0.9
Trichlorobenzene	444	12:35	1747	1.1
Siloxene	454	12:52	14223	8.9
Trichlorobenzene	475	13:27	7663	4.8
Unknown	480	13:36	4687	2.9
Alkene	490	13:53	7015	4.4
Trichlorobenzene	499	14:08	13375	8.4
Unknown	524	14:51	1807	1.1
Alkene	545	15:26	4423	2.8
Unknown	550	15:35	6623	4.2
Siloxane	559	15:50	14175	8.9
Tetrachlorobenzene	569	16:07	9807	6.2
Unknown	585	16:34	2635	1.7
Tetrachlorobenzene	598	16:57	11775	7.4
Siloxane	651	18:27	6135	3.9
Alkane	659	18:40	3607	2.3
Pentachlorobenzene	674	19:06	13583	8.5
Alkane	747	21:10	3595	2.3
Alkene	755	21:23	4831	3.0
Hexachlorobenzene	767	21:44	6575	4.1

(continued)

MONS 217623

Table A-8 (concluded)

Tentative Identification	Scan	RT (min)	Area	Yield[c] (µg/g)
Fluorenone	778	22:03	2255	1.4
Siloxane	786	22:16	18687	12
Siloxane	828	23:28	10927	6.9

[a]Composition from J. V. Zbozinek, J. R. Marsh, D. Guth, and A. Bohrnerud (SCS Engineers, Inc.). State-of-the-Art Review of Combustion and Pyrolysis By-Products of PCB Substitutes. Palo Alto, CA: Electric Power Reseerch Institute, March 1986. EPRI EL-4503.

[b]Amount pyrolyzed = 810 µg.

[c]Yield is computed with respect to the mass of the sample pyrolyzed. Product amounts are determined by comparison of their areas with that of an external anthrecene standard, assuming relative responsas of one. Because of the assumptions implicit in the yield computations, the yield values are only within a factor of five. No internal standard methods or use of authentic standards were used to quantitate the products in this study.

[d]Major component of Formel, overloaded peak. Quantitation unreliable.

MONS 217624

Table A-9

WECOSOL (PERCHLOROETHYLENE)[a], 500°C PYROLYSIS[b]

Tentative Identification	Scan	RT (min)	Area	Yield[c] (µg/g)
Tetrahydromethylfuran	73	2:04	44287	22
Alkane	108	3:04	51327	26
Unknown	163	4:37	1501	0.8
Tetrachloroethylene[d]	184	5:13	61119	31
Unknown	239	6:46	3147	1.6
Unknown	278	7:53	5119	2.6
Siloxane	296	8:23	10543	5.3
Alkane	321	9:06	12127	6.1
Alkene	363	10:17	9887	5.0
Siloxane	401	11:22	24799	13
Trichlorobenzene	424	12:01	38975	20
Alkene	427	12:06	4775	2.4
Trichlorobenzane	447	12:40	21503	11
Unknown	487	13:48	3371	1.7
Ethylideneindene	496	14:03	8255	4.2
Siloxane	505	14:18	26143	13
Unknown	530	15:01	3347	1.7
Biphenyl	541	15:20	9263	4.7
Tetrachlorobenzene	543	15:23	28927	15
Dimethylnaphthalene	565	16:00	3307	1.7
Alkane	578	16:23	4983	2.5
Siloxane	594	16:50	13279	6.7
Alkane	596	16:53	21343	11
Alkane	644	18:15	33087	17
C_3-Alkylbiphenyl	665	18:50	22719	11
Alkane	689	19:31	21311	11
Unknown	709	20:05	5711	2.9
Unknown	728	20:38	12799	6.5
Alkane	733	20:46	16575	8.4
Siloxane	772	21:52	10287	5.2
Alkane	816	23:07	5407	2.7
Alkane	1079	30:34	4151	2.1
Siloxane	1111	31:29	3123	1.6

[a]Composition from J. V. Zbozinek, J. R. Marsh, D. Guth, and A. Bohrnerud (SCS Engineers, Inc.). State-of-the-Art Review of Combustion and Pyrolysis By-Products of PCB Substitutes. Palo Alto, CA: Electric Power Research Institute, March 1986. EPRI EL-4503.

[b]Amount pyrolyzed = 810 µg.

[c]Yield is computed with respect to the mass of the sample pyrolyzed. Product amounts are determined by comparison of their areas with that of an external anthracene standard, assuming relative responses of one. Because of the assumptions implicit in the yield computations, the yield values are only within a factor of five. No internal standard methods or use of authentic standards were used to quantitate the products in this study.

[d]Major component of Wecosol, overloaded peak. Quantitation unreliable.

MONS 217625

Table A-10

WECOSOL (PERCHLOROETHYLENE)[a], 900°C PYROLYSIS[b]

Tentative Identification	Scan	RT (min)	Area	Yield[c] (µg/g)
Trichloroethylene	149	4:13	48191	24
Unknown	282	7:59	1321	0.7
Tetrachloroethylene[d]	289	8:11	2[illegible]3519	150
Unknown	291	8:15	10255	5.2
Chlorinated unknown	325	9:12	24159	12
Siloxane	372	10:32	20319	10
Dichlorobenzene	391	11:05	11247	5.7
Chlorinated unknown	417	11:49	7391	3.7
Alkene	443	12:33	7351	3.7
Alkane	451	12:47	6959	3.5
Siloxene	478	13:33	38143	19
Alkene	507	14:22	4935	2.5
Trichlorobenzene	509	14:25	48191	24
Trichlorobenzene	532	15:04	24575	12
Unknown	577	16:21	5087	2.6
Siloxane	582	16:29	44223	22
Tetrachlorobenzene	631	17:53	26911	14
Unknown	655	18:33	2255	1.1
Siloxane	676	19:09	15647	7.9
Pentachlorobenzene	709	20:05	28447	14
Alkene	729	20:39	5687	2.9
C_5-Alkylbiphenyl	755	21:23	8879	4.5
Hexachlorobenzene	805	22:48	20927	11
Siloxane	817	23:09	15775	8.0
Siloxane	860	24:22	8319	4.2

[a]Composition from J. V. Zbozinek, J. R. Marsh, D. Guth, and A. Bohrnerud (SCS Engineers, Inc.). State-of-the-Art Review of Combustion and Pyrolysis By-Products of PCB Substitutes. Palo Alto, CA: Electric Power Research Institute, March 1986. EPRI EL-4503.

[b]Amount pyrolyzed = 810 µg.

[c]Yield is computed with respect to the mass of the sample pyrolyzed. Product amounts are determined by comparison of their areas with that of an external anthracene standard, assuming relative responses of one. Because of the assumptions implicit in the yield computations, the yield values are only within a factor of five. No internal standard methods or use of authentic standards were used to quantitate the products in this study.

[d]Major component of Wecosol, overloaded peak. Quantitation unreliable.

MONS 217626

Table A-11

WECOSOL (PERCHLOROETHYLENE)[a], 500°C COMBUSTION[b]

Tentative Identification	Scan	RT (min)	Area	Yield[c] (µg/g)
Tetrachloroethylene[d]	284	8:03	229631	120
Chlorobenzene	298	8:27	8031	4.1
Chlorinated unknown	314	8:54	8799	4.4
Chlorinated unknown	340	9:38	9887	5.0
Unknown	358	10:09	6647	3.4
Benzaldehyde	381	10:48	7823	4.0
Siloxane	396	11:13	22047	11
Dichlorobenzene	416	11:47	9487	4.8
Dichlorobenzene	439	12:26	6695	3.4
Unknown	460	13:02	2915	1.5
Cyclopropylcyclohexane	482	13:39	5159	2.6
Siloxane	508	14:24	16671	8.4
Trichlorobenzene	541	15:20	24799	13
Hexachloropropene	560	15:52	6791	3.4
Trichlorobenzene	566	16:02	25119	13
Unknown	603	17:05	1537	0.8
Siloxane	615	17:25	10143	5.1
Tetrachlorobenzene	667	18:54	24319	12
Alkane	714	20:14	7887	4.0
Pentachlorobenzene	746	21:08	14719	7.4
Siloxane	851	24:07	12575	6.4
Siloxane	894	25:20	7399	3.7

[a]Composition from J. V. Zbozinek, J. R. Marsh, D. Guth, and A. Bohrnerud (SCS Engineers, Inc.). State-of-the-Art Review of Combustion and Pyrolysis By-Products of PCB Substitutes. Palo Alto, CA: Electric Power Research Institute, March 1986. EPRI EL-4503.

[b]Amount pyrolyzed = 810 µg.

[c]Yield is computed with respect to the mass of the sample pyrolyzed. Product amounts are determined by comparison of their areas with that of an external anthracene standard, assuming relative responses of one. Because of the assumptions implicit in the yield computations, the yield values are only within a factor of five. No internal standard methods or use of authentic standards were used to quantitate the products in this study.

[d]Major component of Wecosol, overloaded peak. Quantitation unreliable.

MONS 217627

Table A-12

WECOSOL (PERCHLOROETHYLENE)[a], 900°C COMBUSTION[b]

Tentative Identification	Scan	RT (min)	Area	Yield[c] (µg/g)
Tetrahydromethylfuran	103	2:55	61439	31
Trichloroethylene	151	4:17	13903	7.0
Tetrachloroethylene[d]	248	7:02	378367	190
Unknown	313	8:52	8479	4.3
Benzaldehyde	351	9:57	11663	5.9
Siloxane	368	10:26	29311	15
Unknown	380	10:46	12591	6.4
Diethylcyclobutane	400	11:20	23455	12
C_3-Alkylbenzene	436	12:21	6551	3.3
Alkane	457	12:57	14815	7.5
Siloxane	486	13:46	33343	17
Trichlorobenzene	518	14:41	22655	11
Unknown	527	14:56	9935	5.0
Trichlorobenzene	544	15:25	20991	11
Alkane	585	16:34	8655	4.4
Siloxane	596	16:53	35263	18
Tetrachlorobenzene	617	17:29	11567	5.8
Tetrachlorobenzene	647	18:20	29247	15
Unknown	692	19:36	11567	5.8
Pentachlorobenzene	726	20:34	12735	6.4
Alkane	746	21:08	9343	4.7
Alkane	792	22:26	5911	3.0
Siloxane	834	23:38	12927	6.5
Siloxane	876	24:49	7319	3.7

[a]Composition from J. V. Zbozinek, J. R. Marsh, D. Guth, and A. Bohrnerud (SCS Engineers, Inc.). State-of-the-Art Review of Combustion and Pyrolysis By-Products of PCB Substitutes. Palo Alto, CA: Electric Power Research Institute, March 1986. EPRI EL-4503.

[b]Amount pyrolyzed = 810 µg.

[c]Yield is computed with respect to the mass of the sample pyrolyzed. Product amounts are determined by comparison of their areas with that of an external anthracene standard, assuming relative responses of one. Because of the assumptions implicit in the yield computations, the yield values are only within a factor of five. No internal standard methods or use of authentic standards were used to quantitate the products in this study.

[d]Major component of Wecosol, overloaded peak. Quantitation unreliable.

MONS 217628

Table A-13

ELECTROCHEM FR-15 (CHLOROBENZENE MIX)[a], 500°C PYROLYSIS[b]

Tentative Identification	Scan	RT (min)	Area	Yield[c] (µg/g)
Methylene chloride	52	1:28	111743	43
Tetrahydromethylfuran	61	1:44	210175	81
Alkene	88	2:30	234495	90
Toluene	138	3:55	23903	9.2
Tetrachloroethylene	175	4:57	15967	6.1
Siloxane	184	5:13	37951	15
Chlorobenzene	212	6:00	6263	2.4
Xylene	236	6:41	2575	1.0
Alkene	254	7:12	5671	2.2
Siloxane	348	9:52	19263	7.4
Dichlorobenzene	365	10:20	47295	18
Dichlorobenzene	384	10:53	66815	26
$C_7H_5Cl_3$ + C_6H_4BrCl	449	12:43	12831	4.9
Siloxane	464	13:09	57471	22
Trichlorobenzene[d]	509	14:25	26207	10
Trichlorobenzene[d]	544	15:25	16223	6.2
Trichlorobenzene[d]	572	16:12	397311	150
$C_7H_5Cl_3$	577	16:21	20223	7.8
Bromodichlorobenzene	579	16:24	52287	20
Siloxane	583	16:31	38207	15
$C_7H_5Cl_3$	586	16:36	52607	20
$C_7H_5Cl_3$	591	16:45	48255	19
Tetrachlorobenzene[d]	601	17:02	95615	37
Tetrachlorobenzene[d]	639	18:06	13407	5.2
Tetrachlorobenzene[d]	665	18:50	306175	120
Pentachlorobenzene	698	19:47	53503	21
Unknown	792	22:26	8559	3.3
Terphenyl	845	23:56	7511	2.9
Phenylbicyclohexyl	886	25:06	8015	3.1
Unknown	892	25:16	3479	1.3
Unknown	918	26:01	10399	4.0
Hexachlorobiphenyl	1004	28:27	1195	0.5

[a]Composition from J. V. Zbozinek, J. R. Marsh, D. Guth, and A. Bohrnerud (SCS Engineers, Inc.). State-of-the-Art Review of Combustion and Pyrolysis By-Products of PCB Substitutes. Palo Alto, CA: Electric Power Research Institute, March 1986. EPRI EL-4503.

[b]Amount pyrolyzed = 730 µg.

[c]Yield is computed with respect to the mass of the sample pyrolyzed. Product amounts are determined by comparison of their areas with that of an external anthracene standard, assuming relative responses of one. Because of the assumptions implicit in the yield computations, the yield values are only within a factor of five. No internal standard methods or use of authentic standards were used to quantitate the products in this study.

[d]Major component of Electocham FR-15, overloaded peak. Quantitation unreliable.

MONS 217629

Table A-14

ELECTROCHEM FR-15 (CHLOROBENZENE MIX)[a], 900°C PYROLYSIS[b]

Tentative Identification	Scan	RT (min)	Area	Yield[c] (µg/g)
Methylene chloride	51	1:27	114559	44
Tetrahydromethylfuran	65	1:50	144895	56
Alkene	83	2:21	46783	18
Alkene	92	2:36	64191	25
Toluene	142	4:01	31839	12
$C_7H_{10}O$	167	4:44	2291	0.9
Tetrachloroethylene	173	4:54	18015	6.9
Siloxane	182	5:09	28095	11
Chlorobenzene	205	5:48	9695	3.7
Unknown	341	9:40	10095	3.9
Dichlorobenzene	357	10:07	12751	4.9
Dichlorobenzene	362	10:15	14879	5.7
Dichlorobenzene	377	10:41	23743	9.1
Trichlorobenzene[d]	498	14:07	25023	9.6
Trichlorobenzene[d]	539	15:16	14127	5.4
Trichlorobenzene[d]	578	16:23	338943	130
Siloxene	590	16:43	33471	13
Bromodichlorobenzene	592	16:46	77823	30
$C_7H_5Cl_3$	596	16:53	77951	30
$C_7H_5Cl_3$	600	17:00	106495	41
Tetrachlorobenzene[d]	611	17:19	216575	83
Tetrachlorobenzene[d]	638	18:05	40127	15
Tetrachlorobenzene[d]	662	18:45	22431	8.6
$C_7H_4Cl_4$	691	19:35	28895	11
Pentachlorobenzene	706	20:00	119807	46
Unknown	717	20:19	11087	4.3
C_3-Alkylbiphenyl	737	20:53	7375	2.8
Alkene	756	21:25	10447	4.0
Hexachlorobenzene	778	22:03	21343	8.2
Unknown	792	22:26	10479	4.0
Unknown	833	23:36	8383	3.2
Terphenyl	844	23:55	18015	6.9
Unknown	857	24:17	11359	4.4
Phenylbicyclohexyl	883	25:01	34239	13
Unknown	890	25:13	18271	7.0
Unknown	898	25:27	12543	4.8
Phenylbicyclohexyl	903	25:35	23199	8.9

(continued)

MONS 217630

Table A-14 (concluded)

Tentative Identification	Scan	RT (min)	Area	Yield[c] (µg/g)
Unknown	916	25:57	36735	14
$C_{18}H_{20}$	933	26:26	13103	5.0
Terphenyl	942	26:41	8447	3.3
Terphenyl	958	27:09	2067	0.8
Hexachlorobiphenyl	1002	28:23	1533	0.6

[a]Composition from J. V. Zbozinek, J. R. Marsh, D. Guth, and A. Bohrnerud (SCS Engineers, Inc.). State-of-the-Art Review of Combustion and Pyrolysis By-Products of PCB Substitutes. Palo Alto, CA: Electric Power Research Institute, March 1986. EPRI EL-4503.

[b]Amount pyrolyzed = 730 µg.

[c]Yield is computed with respect to the mass of the sample pyrolyzed. Product amounts are determined by comparison of their areas with that of an external anthracene standard, assuming relative responses of one. Because of the assumptions implicit in the yield computations, the yield values are only within a factor of five. No internal standard methods or use of authentic standards were used to quantitate the products in this study.

[d]Major component of Electrochem FR-15, overloaded peak. Quantitation unreliable.

MONS 217631

Table A-15

ELECTROCHEM FR-15 (CHLOROBENZENE MIX)[a], 500°C COMBUSTION[b]

Tentative Identification	Scan	RT (min)	Area	Yield[c] (µg/g)
Methylene chloride	54	1:32	100223	39
Tetrahydromethylfuran	64	1:49	125311	48
Unknown	83	2:21	31551	12
Alkene	93	2:38	66303	26
Toluene	149	4:13	21023	8.1
Tetrachloroethylene	183	5:11	17823	6.9
Siloxane	192	5:26	44607	17
Chlorobenzene	217	6:09	11599	4.5
Unknown	317	8:59	2571	1.0
Benzaldehyde	324	9:11	6607	2.5
Siloxane	350	9:55	29503	11
Dichlorobenzene	366	10:22	65919	25
Dichlorobenzene	385	10:54	94719	36
Bromochlorobenzene	435	12:19	14047	5.4
$C_7H_6Cl_2$	450	12:45	11823	4.5
Siloxane	468	13:16	37631	14
Trichlorobenzene[d]	515	14:35	4287	1.6
Trichlorobenzene[d]	543	15:23	23327	9.0
Trichlorobenzene[d]	582	16:29	294399	110
$C_8H_6Cl_2$	590	16:43	34751	13
Bromodichlorobenzene	594	16:50	87167	34
$C_7H_5Cl_3$	599	16:58	77567	30
Tetrachlorobenzene[d]	616	17:27	130303	50
Tetrachlorobenzene[d]	642	18:11	34879	13
Tetrachlorobenzene[d]	667	18:54	33343	13
$C_7H_4Cl_4$	693	19:38	23327	9.0
Pentachlorobenzene	708	20:04	98431	38
Hexachlorobenzene	782	22:09	14175	5.5
Unknown	796	22:33	9663	3.7
Silane	837	23:43	4943	1.9
Terphenyl	848	24:02	6791	2.6
Terphenyl	947	26:50	3591	1.4

[a]Composition from J. V. Zbozinek, J. R. Marsh, O. Guth, and A. Bohrnerud (SCS Engineers, Inc.). State-of-the-Art Review of Combustion and Pyrolysis By-Products of PCB Substitutes. Palo Alto, CA: Electric Power Research Institute, March 1986. EPRI EL-4503.

[b]Amount pyrolyzed = 730 µg.

[c]Yield is computed with respect to the mass of the sample pyrolyzed. Product amounts are determined by comparison of their areas with that of an external anthracene standard, assuming relative responses of one. Because of the assumptions implicit in the yield computations, the yield values are only within a factor of five. No internal standard methods or use of authentic standards were used to quantitate the products in this study.

[d]Major component of Electrochem FR-15, overloaded peak. Quantitation unreliable.

MONS 217632

Table A-16

ELECTROCHEM FR-15 (CHLOROBENZENE MIX)[a], 900°C COMBUSTION[b]

Tentative Identification	Scan	RT (min)	Area	Yield[c] (µg/g)
Methylene chloride	58	1:39	40511	16
Alkene	79	2:14	64959	25
Unknown	108	3:04	52159	20
Unknown	160	4:32	5247	2.0
Toluene	172	4:52	11727	4.5
Tetrachloroethylene	207	5:52	30239	12
Siloxane	215	6:05	15119	5.8
Chlorobenzene	240	6:48	20639	7.9
Unknown	279	7:54	1673	0.6
Unknown	337	9:33	4263	1.6
Siloxene	367	10:24	19935	7.7
Oichlorobenzene	382	10:49	44607	17
Dichlorobenzene	400	11:20	75391	29
$C_7H_6Cl_2$	463	13:07	15311	5.9
Siloxane	481	13:38	20767	8.0
Trichlorobenzene[d]	529	14:59	10959	4.2
Trichlorobenzene[d]	558	15:49	18239	7.0
Trichlorobenzene[d]	598	16:57	204543	79
Tetrachlorobenzene[d]	630	17:51	205823	79
Tetrachlorobenzene[d]	658	18:39	21919	8.4
Tetrachlorobenzene[d]	683	19:21	38975	15
Unknown	703	19:55	30719	12
$C_7H_4Cl_4$	710	20:07	28575	11
Chlorinated unknown	712	20:10	20799	8.0
Pentachlorobenzene	725	20:32	125183	48
Hexachlorobenzene	798	22:37	24127	9.3
Unknown	811	22:59	19647	7.6
Silane	850	24:05	6527	2.5
Terphenyl	862	24:25	6231	2.4

[a]Composition from J. V. Zbozinek, J. R. Marsh, D. Guth, and A. Bohrnerud (SCS Engineers, Inc.). State-of-the-Art Review of Combustion and Pyrolysis By-Products of PCB Substitutes. Palo Alto, CA: Electric Power Research Institute, March 1986. EPRI EL-4503.

[b]Amount pyrolyzed = 730 µg.

[c]Yield is computed with respect to the mass of the sample pyrolyzed. Product amounts are determined by comparison of their areas with that of an external anthracene standard, assuming relative responses of one. Because of the assumptions implicit in the yield computations, the yield values are only within a factor of five. No internal standard methods or use of authentic standards were used to quantitate the products in this study.

[d]Major component of Electrochem FR-15, overloaded peak. Quantitation unreliable.

MONS 217633

Table A-17

DICY. KRAFT PAPER (TOR-1), 500°C PYROLYSIS[a]

Tentative Identification	Scan	RT (min)	Area	Yield[b] (µg/g)
Ethanyloxypropane	104	1:44	72575	240
Unknown	117	1:57	200703	66
Dichloroethene	122	2:02	22175	73
Unknown	131	2:11	83563	270
Butanedione	146	2:26	84607	280
Methylfuran	153	2:33	60095	200
Methylfuran	161	2:41	41151	140
C_6H_6	195	3:15	611327	2000
Benzene	206	3:26	368127	1200
Dimethylfuran	232	3:52	19839	65
Dimethylfuran	246	4:06	17343	57
Unknown	267	4:27	37887	120
Acetic acid	309	5:09	198911	650
Unknown	326	5:26	280575	920
Unknown	337	5:37	50815	170
Siloxane	363	6:03	20863	68
Unknown	387	6:27	59775	200
Furancarboxaldehyde	397	6:37	118015	390
Chlorobenzene	409	6:49	24735	81
Unknown	415	6:55	103551	340
C_2-Alkylbenzene	438	7:18	15695	51
Styrene	468	7:48	56319	180
Furanmethanol/C_8H_8	476	7:56	116223	380
Unknown	544	9:04	69375	230
Furanone	552	9:12	185343	610
Cyclohexanone	559	9:19	125311	410
Benzaldehyde	571	9:31	72831	240
C_3-Alkenylbenzene	583	9:43	15887	52
Unknown	589	9:49	67071	220
Unknown	601	10:01	13935	46
Unknown	611	10:11	143871	470
Unknown	631	10:31	18271	60
Unknown	641	10:41	38079	120
Hydroxymethylcyclopentenone	671	11:11	168191	550
Unknown	693	11:33	88063	290
Unknown	702	11:42	91263	300
Alkane	710	11:50	220927	720
Unknown	717	11:57	30463	100
Nonanel	722	12:02	126079	410
Unknown	756	12:36	73087	240
Unknown	762	12:42	118271	390
Unknown	782	13:02	33407	110
Alkene	805	13:25	98559	320
Alkane	812	13:32	134911	440
Octanoic acid	816	13:36	99839	330
Naphthalene	823	13:43	49855	160

(continued)

MONS 217634

Table A-17 (continued)

Tentative Identification	Scan	RT (min)	Area	Yield[b] (µg/g)
Benzoic acid	836	13:56	43775	140
Unknown	849	14:09	61119	200
Unknown	881	14:41	57023	190
Unknown	890	14:50	23679	78
Alkene	900	15:00	78847	260
Decanoic acid	987	16:27	132863	440
Cycloalkane	990	16:30	101887	330
Unknown	998	16:38	3031	9.9
Biphenyl	1008	16:48	522239	1700
Alkene	1073	17:53	145919	480
Alkane	1078	17:58	289791	950
Unknown	1150	19:10	175359	580
Alkene	1153	19:13	659455	2200
Alkane	1157	19:17	136191	450
Tetrachlorophenol	1161	19:21	32255	100
Dimethylbenzenebutanoic acid	1168	19:28	182271	600
Unknown	1170	19:30	62079	200
Phthalate ester	1176	19:36	81407	270
$C_{15}H_{18}$	1205	20:05	433151	1400
$C_{15}H_{18}$	1230	20:30	304639	1000
Unknown	1238	20:38	76287	250
$C_{15}H_{14}$	1252	20:52	29823	98
Tetradecanoic acid	1292	21:32	481279	1600
Alkene	1298	21:38	442879	1400
Alkane	1302	21:42	141055	460
Tetradecanal	1320	22:00	83327	270
Unknown	1334	22:14	41791	140
Dodecanoic acid	1353	22:33	167423	550
Alkene	1363	22:43	560127	1800
Hexadecanoic acid	1425	23:45	613375	2000
Phthalate ester	1430	23:50	385535	1300
Unknown	1443	24:03	96383	320
Alkene	1481	24:41	166399	550
Alkene	1491	24:51	539647	1800
Siloxane	1504	25:04	28287	93
Unknown	1510	25:10	44927	150
Unknown	1515	25:15	39423	130
Alkenol	1529	25:29	67199	220
Unknown	1541	25:41	344063	1100
Unknown	1559	25:59	56767	190
Unknown	1573	26:13	60863	200
Terphenyl	1587	26:27	41791	140
Siloxene	1595	26:35	155391	510
Unknown	1619	26:59	189695	620
Phthalate ester	1634	27:14	89727	290
Siloxene	1647	27:27	279551	920
Siloxene	1649	27:29	266239	870
Unknown	1659	27:39	80127	260

(continued)

MONS 217635

Table A-17 (concluded)

Tentative Identification	Scan	RT (min)	Area	Yield[b] (µg/g)
Phthalate ester	1668	27:48	276263	910
Unknown	1670	27:50	102527	340
Unknown	1691	28:11	55295	180
Unknown	1709	28:29	79359	260
Unknown	1719	28:39	28223	93
Unknown	1727	28:47	78335	260
Unknown	1738	28:58	340479	1100
Unknown	1751	29:11	381951	1200
Phthalate ester	1770	29:30	439295	1400
Phthalate ester	1779	29:39	65663	220
Unknown	1827	30:27	28191	93
Alkene	1848	30:48	13439	44
Unknown	1872	31:12	8751	29
Unknown	1895	31:35	26111	86
Unknown	1918	31:58	9567	31
Unknown	1945	32:25	3983	13
Siloxane	1964	32:44	52671	170
Unknown	1990	33:10	4767	16
Siloxane	2058	34:18	105343	340
Siloxane	2083	34:43	37183	120

[a]Amount pyrolyzed = 92 µg.

[b]Yield is computed with respect to the mass of the sample pyrolyzed. Product amounts are determined by comparison of their areas with that of an external anthracene standard, assuming relative responses of one. Because of the assumptions implicit in the yield computations, the yield values are only within a factor of five. No internal standard methods or use of authentic standards were used to quantitate the products in this study.

Table A-18

DICY. KRAFT PAPER (TOR-1), 900°C PYROLYSIS[a]

Tentative Identification	Scan	RT (min)	Area	Yield[b] (µg/g)
C_5H_4	126	2:06	90111	360
Unknown	130	2:10	205055	800
Unknown	194	3:14	344575	1400
Benzene	205	3:25	366591	2600
Toluene	310	5:10	532479	2100
C_7H_8	327	5:27	413183	1600
Siloxane	366	6:06	138239	550
Siloxane	383	6:23	76799	310
Chlorobenzene	428	7:08	168703	670
C_8-Alkylbenzene	446	7:26	336895	1300
C_8-Alkylbenzene	456	7:36	182271	720
Unknown	469	7:49	67967	270
Styrene	472	7:52	383999	1500
C_8H_8	491	8:11	678911	2700
C_9-Alkenylbenzene	552	9:12	246015	980
Benzaldehyde	577	9:37	232703	930
Siloxane	585	9:45	46847	190
Siloxane	591	9:51	59775	240
C_9-Alkenylbenzene	595	9:55	516607	2100
C_9-Alkenylbenzene	606	10:06	103423	410
Dihydroindene	613	10:13	177663	710
C_9-Alkenylbenzene	641	10:41	47039	190
C_9-Alkenylbenzene	646	10:46	235007	930
Indene	674	11:14	584703	2300
$C_{11}H_{22}$	704	11:44	319999	1300
Alkene	712	11:52	371199	1500
Unknown	723	12:03	138495	550
Siloxane	758	12:38	76287	300
$C_{10}H_{10}$	783	13:03	245759	980
Naphthalene	794	13:14	107007	430
$C_{10}H_{10}$	802	13:22	138495	550
Alkene	805	13:26	355839	1400
Alkane	813	13:33	178175	710
$C_{10}H_8$	826	13:46	432127	1900
Alkene	901	15:01	304127	1200
Siloxane	922	15:22	86911	340
Methylnaphthalene	932	15:32	137727	550
Methylnaphthalene	949	15:49	133375	530
Alkene	993	16:33	293887	1200
Alkane	999	16:39	226303	900
Biphenyl	1013	16:53	501247	2000
Methylbiphenyl	1022	17:02	146175	580
Methylbiphenyl	1051	17:31	103551	410
Siloxane	1070	17:50	76671	310
Alkene	1074	17:54	359423	1400
Alkene	1079	17:54	492543	2000

(continued)

MONS 217637

Table A-18 (concluded)

Tentative Identification	Scan	RT (min)	Area	Yield[b] (µg/g)
Methylbiphenyl	1095	18:15	239103	950
$C_{13}H_{12}$	1104	18:24	156927	620
Alkene	1154	19:14	347647	1400
Dodecanoic acid	1163	19:23	295935	1200
Dimethylbenzenebutanoic acid	1176	19:36	184063	730
Phthalate ester	1181	19:41	86271	340
Fluorene	1191	19:51	465375	1900
$C_{15}H_{16}$	1211	20:11	422399	1700
Unknown	1217	20:17	53311	210
Alkene	1229	20:29	251903	1000
$C_{15}H_{16}$	1237	20:37	419327	1700
$C_{13}H_{14}$	1254	20:54	142591	570
$C_{14}H_{12}$	1273	21:13	102271	410
$C_{15}H_{14}$	1282	21:22	93823	370
Unknown	1288	21:28	58175	230
Tetradecenoic acid	1296	21:36	252927	1000
Alkene	1299	21:39	300031	1200
Alkane	1303	21:43	266239	1100
Phenanthrene/anthracene	1340	22:20	269311	1100
2-Methylhexadecanol	1364	22:44	473087	1900
Hexedecenoic acid	1425	23:45	410623	1600
Phthalate ester	1430	23:50	454655	1800
Alkene	1481	24:41	127231	510
Unknown	1491	24:51	430591	1700
Alkanoic acid	1537	25:37	146943	580
Unknown	1597	26:37	245503	980
Unknown	1651	27:31	241919	960
Unknown	1747	29:07	61887	250
Phthalate ester	1767	29:27	212223	840
Unknown	2052	34:12	29663	120

[a]Amount pyrolyzed = 76 µg.

[b]Yield is computed with respect to the mass of the sample pyrolyzed. Product amounts are determined by comparison of their areas with that of an external anthracene standard, assuming relative responses of one. Because of the assumptions implicit in the yield computations, the yield values are only within a factor of five. No internal standard methods or use of authentic standards were used to quantitate the products in this study.

MONS 217638

Table A-19

DICY. KRAFT PAPER (TOR-1), 500°C COMBUSTION[a]

Tentative Identification	Scan	RT (min)	Area	Yield[b] (µg/g)
Unknown	82	1:22	11983	57
Unknown	102	1:42	23231	110
Unknown	114	1:54	180991	870
Dichloroethene	120	2:00	28063	130
Methylene chloride/dichloroethene	124	2:04	25279	120
2-Propenylformate	130	2:10	23871	110
Unknown	146	2:26	60799	290
Unknown	151	2:31	72063	340
Benzene	196	3:16	624638	3000
Alkane	207	3:27	82559	400
Unknown	221	3:41	56767	270
Unknown	230	3:50	57727	280
Unknown	250	4:10	6399	31
Acetic acid	282	4:42	154111	740
Hexanal	343	5:43	99071	470
Hexanal	353	5:53	60543	290
Siloxane	362	6:02	24607	120
Furencarboxaldehyde	367	6:07	37887	180
Unknown	382	6:22	39423	190
Furancarboxaldehyde	395	6:35	159999	770
Chlorobenzene	415	6:55	51583	250
Heptanal	477	7:57	95615	460
Methylhexenal	487	8:07	146687	700
Benzaldehyde	570	9:30	113535	540
Unknown	574	9:34	33791	160
Siloxane	587	9:47	29983	140
Phenol	598	9:58	50623	240
Benzonitrile	600	10:00	19391	93
Octanal	610	10:10	362495	1700
Cycloalkane	639	10:39	41023	200
2-Decenal	674	11:14	38975	190
Cycloalkane	685	11:25	35455	170
Acetophenone	693	11:33	39167	190
Alkene	701	11:41	40127	190
Alkane	709	11:49	114687	550
Nonanal	722	12:02	348671	1700
Ethylhexanoic acid	739	12:19	29119	140
Siloxane	756	12:36	71295	340
Alkene	781	13:01	53311	260
Alkane	812	13:32	152063	730
Dodecanal	824	13:44	293375	1400
Trichlorobenzene	850	14:10	45567	220
Unknown	881	14:41	62335	300
Nonanoic acid	889	14:49	71679	340
Unknown	905	15:05	3503	17
Undecanal	920	15:20	317951	1500

(continued)

MONS 217639

Table A-19 (concluded)

Tentative Identification	Scan	RT (min)	Area	Yield[b] (µg/g)
Unknown	973	16:13	90751	440
Methylpropanoic acid, hydroxyoctyl ester	990	16:30	163327	780
Alkane	995	16:35	123007	590
Biphenyl	1004	16:44	66431	320
Tetradecenel	1009	16:49	153855	740
Siloxane	1070	17:50	51967	250
Alkene	1073	17:53	70911	340
Alkane	1078	17:58	119167	570
Tridecanal	1094	18:14	178431	860
Dodecanoic acid	1136	18:56	93311	450
Alkene	1152	19:12	179199	860
Alkane	1157	19:17	124287	600
Propanoic acid, alkyl ester	1169	19:29	274431	1300
Diethyl phthalate	1172	19:32	54527	260
Alkane aldehyde	1174	19:34	129407	620
Unknown	1177	19:37	5719	27
Siloxane	1201	20:01	22975	110
$C_{15}H_{16}$	1204	20:04	340991	1600
Alkene	1220	20:20	43647	210
Alkane	1231	20:31	120063	560
Unknown	1236	20:36	72959	350
Alkane aldehyde	1248	20:48	128767	620
Alkene	1297	21:37	131839	630
Unknown	1305	21:45	10063	48
Alkane aldehyde	1319	21:59	130303	620
Unknown	1337	22:17	8367	40
Unknown	1362	22:42	71423	340
Alkane nitrile	1377	22:57	23135	110
Alkane aldehyde	1386	23:06	12367	59
Phthalate ester	1426	23:46	67327	320
Unknown	1490	24:50	24735	120
Unknown	1549	25:49	8255	40
Siloxane	1594	26:34	5311	25
Siloxane	1645	27:25	15791	76
Unknown	1667	27:47	5671	27
Unknown	1746	29:06	11679	56
Unknown	1767	29:27	14223	68
Unknown	1953.	32:33	2059	10
Unknown	2053	34:13	7359	35
Unknown	2075	34:35	3215	15

[a]Amount pyrolyzed = 63 µg.

[b]Yield is computed with respect to the mass of the sample pyrolyzed. Product amounts are determined by comparison of their areas with that of an external anthracene standard, assuming relative responses of one. Because of the assumptions implicit in the yield computations, the yield values are only within a factor of five. No internal standard methods or use of authentic standards were used to quantitate the products in this study.

MONS 217640

Table A-20

DICY. KRAFT PAPER (TOR-1), 900°C COMBUSTION[a]

Tentative Identification	Scan	RT (min)	Area	Yield[b] (µg/g)
Unknown	116	1:56	302591	910
Benzene	192	3:12	405503	1200
Unknown	208	3:28	70527	210
Dimethylfuran	231	3:51	16831	51
Toluene	305	5:05	643070	1940
Siloxane	363	6:03	380415	1100
Siloxane	368	6:08	57023	170
Siloxane	374	6:14	45823	140
Chlorobenzene	408	6:48	290815	880
C_2-Alkylbenzene	427	7:07	194047	590
Styrene	472	7:52	585727	1800
C_8H_8	481	8:01	381951	1200
C_3-Alkenylbenzene	538	8:58	54975	170
C_3-Alkenylbenzene	548	9:08	71679	220
Unknown	557	9:17	29919	90
Benzaldehyde	566	9:26	383487	1200
Benzaldehyde	583	9:43	430591	1300
Siloxane	585	9:45	187647	570
Siloxane	591	9:51	37631	110
C_3-Alkenylbenzene	594	9:54	132095	400
Benzonitrile	608	10:08	245503	740
Chlorophenol	612	10:12	47551	14
Benzofuran	618	10:18	192767	580
Phenol	630	10:30	195071	590
C_3-Alkenylbenzene	646	10:46	116735	350
Dichlorobenzene	661	11:01	56063	170
C_9H_8	665	11:05	121855	370
Indene	673	11:13	446463	1300
Methylphenol	682	11:22	243711	740
C_8H_8O	693	11:33	59263	180
Acetophenone	703	11:43	398847	1200
Methylbenzaldehyde	716	11:56	131839	400
Unknown	722	12:02	58303	180
Unknown	736	12:16	83455	250
Phenylpropenal	741	12:21	84095	250
Siloxane	752	12:32	46911	140
C_4-Alkylbenzene	766	12:46	162559	490
Methyl-1H-indene	785	13:05	106623	320
Unknown	785	13:15	146175	440
Cycloalkane	808	13:28	142335	430
Naphthalene	829	13:49	469503	1400
Trichlorobenzene	853	14:13	71679	220
Unknown	857	14:17	42303	130
Nonanoic acid	914	15:14	121087	360
Undecanal	923	15:23	198143	600
Dihydroindenone	930	15:30	305151	920

(continued)

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Table A-20 (concluded)

Tentative Identification	Scan	RT (min)	Area	Yield[b] (µg/g)
Alkene	995	16:35	102143	310
Biphenyl	1018	16:58	503807	1500
Methylbiphenyl	1025	17:05	131839	400
Methylbiphenyl	1052	17:32	134655	410
Alkene	1075	17:55	162303	490
Methylbiphenyl	1096	18:16	264703	800
C_3-Alkenylnaphthalene	1105	18:25	156671	470
Hydroxybiphenyl	1130	18:50	163071	490
Dibenzofuran	1135	18:55	531455	1600
Alkene	1154	19:14	477695	1400
Dimethylbenzenebutanoic acid	1168	19:28	145919	440
Fluorene	1188	19:48	397823	1200
C_2-Alkenylbiphenyl	1195	19:55	79487	240
$C_{25}H_{16}$	1206	20:06	210175	630
Alkene	1228	20:28	72831	220
$C_{15}H_{16}$	1232	20:32	128895	390
$C_{14}H_{12}$	1272	21:12	75007	230
Tetradecanoic acid	1291	21:31	294911	890
Alkene	1300	21:40	220927	670
Unknown	1303	21:43	129791	390
Fluorenone	1312	21:52	387071	1200
Phenanthrene	1341	22:21	390143	1200
Alkene	1364	22:44	236031	710
Siloxane	1368	22:48	107391	320
Terphenyl	1399	23:19	55231	170
Hexadecanoic acid	1422	23:42	452095	1400
Phthalate ester	1431	23:51	440831	1300
Phenylnaphthalene	1461	24:21	94335	280
Alkene	1491	24:51	192511	580
Alkanoic acid	1538	25:38	166655	500
Terphenyl	1562	26:02	209407	630
Terphenyl	1588	26:28	84095	250
Unknown	1597	26:37	165375	500
Unknown	1618	26:58	127871	390
Unknown	1650	27:30	275455	830
Phthalate ester	1667	27:47	79359	240
Unknown	1737	28:57	180223	540
Unknown	1750	29:10	225535	680
Phthalate ester	1769	29:29	181759	550
Unknown	1832	30:32	54271	160
Unknown	1966	32:46	81791	250
Siloxane	2059	34:19	158743	480
Unknown	2081	34:41	127999	390

[a] Amount pyrolyzed = 100 µg.

[b] Yield is computed with respect to the mass of the sample pyrolyzed. Product amounts are determined by comparison of their areas with that of an external anthracene standard, assuming relative responses of one. Because of the assumptions implicit in the yield computations, the yield values are only within a factor of five. No internal standard methods or use of authentic standards were used to quantitate the products in this study.

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Table A-21

DICY. CREPE PAPER (TOR-4), 900°C PYROLYSIS

Tentative Identification	Scan	RT (min)	Area
Unknown	72	1:12	32064
Unknown	81	1:21	19520
Methylfuran	87	1:27	107776
Cyclohexadiene	95	1:35	28544
Benzene	101	1:41	65920
Unknown hydrocarbon	111	1:51	22432
Unknown	117	1:57	56064
Unknown	121	2:01	47680
Unknown	125	2:05	14752
Methylpyrrole	133	2:13	31584
Toluene	146	2:26	52352
Methylbutenal	157	2:37	45568
Unknown	164	2:44	21216
Unknown	167	2:47	17696
Pyridine	171	2:51	27360
Siloxane	183	3:03	67328
Methylphenol	188	3:08	23488
Unknown	199	3:19	80128
Unknown	213	3:33	67328
Ethylbenzene	216	3:36	41151
Unknown	221	3:41	26432
Unknown	229	3:49	13248
Dimethylbenzene	234	3:54	22368
Furfuryl alcohol	245	4:05	39488
Methylcyclopentenone	250	4:10	33216
Unknown	258	4:18	6072
Furanylethanone	265	4:25	36672
Unknown	280	4:40	8976
Unknown	286	4:46	21216
Phenylethanone	290	4:50	28256
Methylfurfural	311	5:11	53888
Methylcyclopentenone	318	5:18	30112
Methylbutenal	326	5:26	38976
Unknown	335	5:35	18368
Unknown	339	5:39	17888
Phenol	354	5:54	52288
Indene	362	6:02	21792
Unknown	374	6:14	27296
Methylcyclopentanedione	400	6:40	41152
Cresol	407	6:47	18304
Unknown	416	6:56	35072
Cresol	425	7:05	45760
Unknown	432	7:12	20128
C_4-Alkenylbenzene	454	7:34	27456
C_4-Alkenylbenzene Siloxane	459	7:39	23744

(continued)

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Table A-21 (concluded)

Tentative Identification	Scan	RT (min)	Area
Xylenol	476	7:56	41664
Unknown	498	8:18	19264
Dimethoxybenzene	504	8:24	18080
Unknown	530	8:50	18208
Unknown	558	9:18	24544
Benzenediol	565	9:25	19200
Ethoxyphenol	570	9:30	12624
Dihydroindenone	578	9:38	27648
Unknown	586	9:46	39040
Unknown	597	9:57	28448
Siloxane	601	10:01	15424
Unknown	628	10:28	7432
Tetrahydronaphthalenol	634	10:34	15152
Unknown	649	10:49	9760
Unknown	678	11:18	12304
Eugenol	703	11:43	10848
Methylfluorene	873	14:33	3016
Methylfluorene	879	14:39	2644
Unknown	925	15:25	9072

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Table A-22

NITRILE RUBBER (TOR-9), 500°C PYROLYSIS[a]

Tentative Identification	Scan	RT (min)	Area	Yield[b] (µg/g)
Benzene	186	3:06	790527	2800
C_6H_6	218	3:38	573439	2000
C_2-Alkylbenzene	453	7:33	22783	80
Styrene	467	7:47	125951	440
C_8H_8	483	8:03	191487	680
Unknown	501	8:21	141311	500
C_2-Alkenylbenzene	550	9:10	67967	240
Benzaldehyde	574	9:34	89727	320
Alkene	586	9:46	85503	300
Unknown	593	9:53	278015	980
Unknown	599	9:59	64703	230
Phenol	609	10:09	171775	600
Alkene	644	10:44	141311	500
C_3-Alkenylbenzene	660	11:00	97919	340
Indene	673	11:13	349695	1200
Acetophenone	696	11:36	93311	330
Unknown	703	11:43	78591	280
Cycloalkane	705	11:45	158207	560
Alkane	714	11:54	499199	1800
C_3-Alkenyloxybenzene	729	12:09	26495	94
Unknown	735	12:15	66047	230
3-Dihydroindole	760	12:40	122367	430
C_4-Alkadienylbenzene	784	13:04	75135	260
Unknown	791	13:11	29343	100
Unknown	807	13:27	250111	880
Benzoic acid	833	13:53	68479	240
Benzothiazole	871	14:31	297983	1000
Alkene	903	15:03	185599	660
Alkane	910	15:10	458751	1600
Unknown	913	15:13	41343	140
Nonanoic acid	920	15:20	246783	870
$C_{13}H_{18}$	937	15:37	83711	300
Alkene	992	16:32	343551	1200
Decanoic acid/Tetradecane	998	16:38	419839	1500
C_3-Alkyldihydroquinoline	1064	17:44	193279	680
Alkene	1076	17:56	310783	1100
Alkane	1082	18:02	747519	2600
Alkene	1156	19:16	377343	1300
Unknown	1158	19:18	76927	270
Dodecanoic acid	1169	19:29	395775	1400
Phthalate ester	1178	19:38	120191	420
Dimethylbenzenebutanoic acid	1182	19:42	354815	1200
Methylthiobenzothiazole acid	1203	20:03	102655	360
N-phenylbenzenamine	1209	20:09	110207	390
Tridecanoic acid	1224	20:24	169727	600
Alkene	1230	20:30	218111	770

(continued)

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Table A-22 (concluded)

Tentative Identification	Scan	RT (min)	Area	Yield[b] (µg/g)
Alkane	1234	20:34	466943	1600
Alkadiene	1291	21:31	102911	360
Tetradecanoic acid	1299	21:39	186111	660
Alkene	1301	21:41	583679	2100
Unknown	1303	21:43	251391	890
Pentadecanoic acid	1360	22:40	269823	950
Unknown	1367	22:47	815103	2900
Hexadecanoic acid	1429	23:49	461823	1600
Phthalate ester	1434	23:54	275455	970
Unknown	1449	24:09	99711	350
Unknown	1485	24:45	351231	1200
Alkane	1495	24:55	765951	2700
Unknown	1508	25:08	257791	910
Octadecanoic acid	1543	25:43	390655	1400
Siloxane	1598	26:38	190719	670
Siloxane	1649	27:29	269311	950
Unknown	1740	29:00	120831	430
Unknown	1752	29:12	153599	540
Phthalate ester	1775	29.35	1069050	3800
Unknown	1782	29:42	195071	690
Alkatriene nitrile	1974	32:54	143359	510
Unkown	2060	34:20	73471	260

[a]Amount pyrolyzed = 82 µg.

[b]Yield is computed with respect to the mass of the sample pyrolyzed. Product amounts are determined by comparison of their areas with that of an external anthracene standard, assuming relative responses of one. Because of the assumptions implicit in the yield computations, the yield values are only within a factor of five. No internal standard methods or use of authentic standards were used to quantitata the products in this study.

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Table A-23

NITRILE RUBBER (TOR-9), 900°C PYROLYSIS[a]

Tentative Identification	Scan	RT (min)	Area	Yield[b] (µg/g)
Unknown	103	1:43	119039	560
Cyclohexadiene	159	2:39	148479	700
Benzene	174	2:54	389631	1800
C_6H_8	192	3:12	96511	460
Heptene	197	3:17	194047	920
C_6H_8	211	3:31	336383	1600
Toluene	307	5:07	291327	1400
C_8H_{16}	316	5:16	315903	1500
C_7H_8	320	5:20	319999	1500
Siloxane	353	5:53	79359	380
Siloxane	379	6:19	60095	280
C_2-Alkylbenzene	445	7:25	452095	2100
C_2-Alkylbenzene	455	7:35	312319	1500
Styrene	463	7:43	313855	1500
C_8H_8	492	8:12	632831	3000
C_8H_7N	527	8:47	117759	560
C_3-Alkanylbenzene	553	9:13	347135	1600
C_3-Alkylbenzene	561	9:21	160255	760
Benzaldehyde	576	9:36	286719	1400
Methylfurancarboxaldehyde	579	9:39	36159	170
Siloxane	592	9:52	77439	370
C_3-Alkanylbenzene	596	9:56	807935	3800
Benzonitrile	607	10:07	286719	1400
Phenol	610	10:10	130559	620
C_3-Alkanylbenzene	612	10:12	259583	1200
C_3-Alkanylbenzene	616	10:16	159487	760
C_4-Alkanylbenzene	642	10:42	36863	170
C_3-Alkenylbenzene	648	10:48	297983	1400
C_3-Alkenylbenzene	661	11:01	169215	800
Unknown	669	11:09	159231	760
Indene	677	11:17	727039	3400
Acetophenone	699	11:39	281599	1300
Cycloalkane	707	11:47	528383	2500
Alkane	715	11:55	644095	3000
Methylbenzonitrile	724	12:04	115327	550
Nonanal	726	12:06	193791	920
Unknown	729	12:09	54015	260
C_3-Alkynyloxybenzene	737	12:17	45823	220
Unknown	743	12:23	72703	340
Unknown	772	12:52	81663	390
C_4-Alkadienylbenzene	786	13:06	444927	2100
Methylindene	792	13:12	210431	1000
Naphthalene	797	13:17	184575	880
Methylindene	804	13:24	227583	1100
Alkene	809	13:29	662527	3100
Alkane	816	13:36	296447	1400

(continued)

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Table A-23 (continued)

Tentative Identification	Scan	RT (min)	Area	Yield[b] (µg/g)
$C_{10}H_8$	830	13:50	431103	2000
Benzothiazole	873	14:33	332287	1600
Alkene	904	15:04	462847	2200
Alkane	911	15:11	509951	2400
Unknown	913	15:13	64703	310
Nonanoic acid	923	15:23	265727	1300
Siloxane	925	15:25	46591	320
Ethylideneindene	934	15:34	277503	1300
Ethylideneindene	952	15:52	263679	1200
Alkene	996	16:36	526335	2500
Alkane	1002	16:42	423423	2000
Biphenyl	1016	16:56	497151	2400
Methylbiphenyl	1025	17:05	245247	1200
Methylbiphenyl	1054	17:34	178431	850
Alkane	1077	17:57	483327	2300
Acenaphthylene	1080	18:00	135679	640
Alkane	1083	18:03	642047	3000
Methylbiphenyl	1099	18:19	279551	1300
Methylbiphenyl	1107	18:27	212223	1000
Alkene	1157	19:17	360447	1700
Dodecanoic acid	1170	19:30	545791	2600
Phthalate ester	1181	19:41	274431	1300
Dimethylbenzenebutanoic acid	1184	19:44	309247	1500
Fluorene	1195	19:55	528383	2500
(1,2-Ethenediyl)bis-benzene	1198	19:58	140031	660
Methylfluorene	1204	20:04	126847	600
Methylfluorene	1217	20:17	70527	330
Alkene	1230	20:30	323071	1500
Alkene	1235	20:35	337407	1600
Methylfluorene	1275	21:15	168447	800
Cycloalkane	1302	21:42	548863	2600
Unknown	1333	22:13	75519	360
Phenanthrene	1344	22:24	399359	1900
Anthracene	1350	22:30	92543	440
Unknown	1367	22:47	548863	2600
Phthalate ester	1431	23:51	282111	1300
Phthalate ester	1434	23:54	377343	1800
Hexadecanoic acid	1438	23:58	428031	2000
Unknown	1455	24:15	159487	760
Unknown	1486	24:46	334847	1600
Alkanol	1495	24:55	617471	2900
Unknown	1508	25:08	176127	840
Octadecanoic acid	1550	25:50	420863	2000
Siloxane	1601	26:41	295935	1400
Unknown	1654	27:34	296959	1400
Phthalate ester	1672	27:52	210687	1000
Unknown	1676	27:56	102655	490
Alkyl amide	1678	27:58	213247	1000

(continued)

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Table A-23 (concluded)

Tentative Identification	Scan	RT (min)	Area	Yield[b] (µg/g)
Unknown	1743	29:03	184319	870
Unknown	1755	29:15	241919	1100
Phthalate ester	1777	29:37	1146870	5400
Phthalate ester	1779	29:39	1067000	5100
Unknown	1784	29:44	240383	1100
Unknown	1786	29:46	101375	480

[a]Amount pyrolyzed = 61 µg.

[b]Yield is computed with respect to the mass of the sample pyrolyzed. Product amounts are determined by comparison of their areas with that of an external enthracene standard, assuming relative responses of one. Because of the assumptions implicit in the yield computations, the yield values are only within a factor of five. No internal standard methods or use of authentic standards were used to quantitate the products in this study.

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Table A-24

NITRILE RUBBER (TOR-9), 500°C COMBUSTION[a]

Tentative Identification	Scan	RT (min)	Area	Yield[b] (µg/g)
Methylfuran	152	2:32	27839	200
Benzene	194	3:14	681983	4800
C_8H_8	213	3:33	395263	2800
Toluene	303	5:03	69119	490
Chlorobenzene	426	7:06	73471	520
Styrene	469	7:49	51263	360
C_8H_8	482	8:02	162303	1200
Heptanal	493	8:13	345087	2400
Benzaldehyde	578	9:38	484351	3400
Ethoxybenzene	683	9:43	50815	360
C_3-Alkenylbenzene	593	9:53	113535	800
Unknown	595	9:55	41599	290
Benzonitrile	606	10:06	124543	880
Phenol	613	10:13	219647	1600
Unknown	616	10:16	361471	2600
Carbamic acid, Phenyl ester	618	10:18	214271	1500
C_3-Alkenylbenzene	661	11:01	84863	600
Indene	672	11:12	163583	1200
Acetophenone	693	11:33	39487	280
1-Phenylethenone	699	11:39	216831	1500
C_4-Alkenylbenzene	715	11:55	78079	550
Nonanal	727	12:07	450559	3200
Dihydroindenone	792	13:12	46143	320
Methylphenylethanone	822	13:42	68095	480
Decanal	829	13:49	357375	2500
Benzothiazole	874	14:34	42591	300
Nonanoic acid	908	15:08	124543	880
Undecanal	924	15:24	408063	2900
Decanoic acid	988	16:28	89983	640
Alkene	992	16:32	118911	840
Biphenyl	1008	16:48	255231	1800
Dodecanal	1013	16:53	212223	1500
Cycloalkene	1075	17:55	110463	780
Dodecanoic acid	1152	19:12	226303	1600
Alkene	1155	19:15	187647	1300
Dimethylbenzenebutanoic acid	1166	19:26	139775	990
Phthalate ester	1177	19:37	112895	800
Tridecanoic acid	1216	20:16	50303	360
Unknown	1240	20:40	138239	980
Tetradecanoic acid	1291	21:31	372735	2600
Alkene	1300	21:40	247295	1700
Pentadecanoic acid	1355	22:35	100607	710
Alkene	1365	22:45	410623	2900
Alkylnitrile	1381	23:01	128127	900
Alkene	1398	23:18	82303	580
Hexadecanoic acid	1424	23:44	452607	3200

(continued)

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Table A-24 (concluded)

Tentative Identification	Scan	RT (min)	Area	Yield[b] (µg/g)
Phthalate ester	1432	23:52	427007	3000
Unknown	1484	24:44	137727	970
Unknown	1506	25:06	104063	730
Alkylnitrile	1508	25:08	162047	1100
Alkanoic acid	1540	25:40	196607	1400
Unknown	1598	26:38	143359	1000
Unknown	1610	26:50	161023	1100
Unknown	1651	27:31	242175	1700
Phthalate ester	1670	27:50	229631	1600
N-Propylbenzamide	1744	29:04	118271	830
Unknown	1753	29:13	213247	1500
Phthalate ester	1777	29:37	1097720	7700
Phthalate ester	1782	29:42	144383	1000
Unknown	2060	34:20	127615	900
Unknown	2080	34:40	86655	610
Unknown	2173	36:13	2004990	14000
Unknown	2178	36:18	1349630	9500

[a]Amount pyrolyzed = 41 µg.

[b]Yield is computed with respect to the mass of the sample pyrolyzed. Product amounts are determined by comparison of their areas with that of an external anthracene standard, assuming relative responses of one. Because of the assumptions implicit in the yield computations, the yield values are only within a factor of five. No internal standard methods or use of authentic standards were used to quantitate the products in this study.

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Table A-25

NITRILE RUBBER (TOR-9), 900°C COMBUSTION[a]

Tentative Identification	Scan	RT (min)	Area	Yield[b] (µg/g)
Butene	132	2:12	407039	2800
Propenenitrile	142	2:22	206591	1400
Methylpropanedinitrile	148	2:28	44159	300
Benzene	212	3:32	501759	3400
C_6H_6	223	3:43	454655	3100
Unknown	253	4:13	48447	330
Toluene	322	5:22	529407	3600
C_7H_8	328	5:28	329727	2300
C_7H_8	339	5:39	407039	2800
Siloxane	376	6:16	140543	970
Siloxane	382	6:22	36927	250
Siloxane	390	6:30	63551	440
Chlorobenzene	421	7:01	163839	1100
Chlorobenzene	435	7:15	311711	2100
C_2-Alkylbenzene	439	7:19	105727	730
C_2-Alkylbenzene	444	7:24	36351	250
C_2-Alkylbenzene	451	7:31	370687	2600
C_2-Alkylbenzene	461	7:41	179199	1200
Styrene	484	8:04	311807	2100
C_8H_8	492	8:12	764927	5300
Methoxybenzene	521	8:41	63359	440
Unknown	549	9:09	18495	130
C_3-Alkenylbenzene	554	9:14	86399	600
Benzaldehyde	585	9:45	624639	4300
Siloxane	590	9:50	42495	290
C_3-Alkenylbenzene	598	9:58	185087	1300
Phenol	605	10:05	278526	1900
Unknown	613	10:13	123391	850
Benzonitrile	615	10:15	283647	2000
Benzofuran	622	10:22	375295	2600
Ethoxybenzene	625	10:25	254207	1800
C_3-Alkenylbenzene	649	10:49	168959	1200
Unknown	651	10:51	159231	1100
Unknown	664	11:04	81023	560
Unknown	668	11:08	61055	420
Methylphenol	684	11:24	153599	1100
Acetophenone	704	11:44	487935	3400
Alkene	707	11:47	218367	1500
Methylbenzaldehyde	718	11:58	135679	940
Methylbenzonitrile	727	12:07	137471	950
C_3-Alkynyloxybenzene	738	12:18	65919	450
Unknown	742	12:22	122239	840
C_4-Alkylbenzene	767	12:47	123007	850
C_4-Alkenylbenzene	787	13:07	157951	1100
Dihydroindenone	795	13:15	99327	680
Naphthalene	797	13:17	149759	1000

(continued)

MONS 217652

Table A-25 (continued)

Tentative Identification	Scan	RT (min)	Area	Yield[b] (µg/g)
Methylindene	805	13:25	91775	630
Alkene	810	13:30	229119	1600
$C_{10}H_8$	829	13:49	567295	3900
$C_{10}H_8$	831	13:51	553983	3800
Benzothiophene	838	13:58	105727	730
Quinoline	893	14:53	85119	590
Cycloalkane	903	15:03	194047	1300
Undecanal	925	15:25	195071	1300
Dihydroindenone	930	15:30	330751	2300
Methylnaphthalene	934	15:34	204799	1400
Methylnaphthalene	952	15:52	168959	1200
Alkene	997	16:37	199167	1400
Biphenyl	1017	16:57	559103	3800
Methylbiphenyl	1026	17:06	124159	860
Methylbiphenyl	1054	17:34	101631	700
Dimethylquinoline	1074	17:54	98303	680
Unknown	1076	17:56	216319	1500
Methylbiphenyl	1098	18:18	230911	1600
Methylbiphenyl	1107	18:27	145919	1000
Dibenzofuran	1137	18:57	454655	3100
Alkene	1156	19:16	478719	3300
Dodecanoic acid	1158	19:18	393727	2700
Dimethylbenzenebutanoic acid	1173	19:33	218879	1500
Fluorene	1189	19:49	357887	2500
Diphenylethene	1197	19:57	85119	590
Diphenylmethanone	1218	20:18	104447	720
Alkene	1230	20:30	107775	740
Diphenylethene	1274	21:14	78975	540
Tetradecanoic acid	1296	21:36	329727	2300
Alkene	1301	21:41	247295	1700
Fluorenone	1313	21:53	410111	2800
Anthracene	1343	22:23	453119	3100
Alkene	1366	22:46	364031	2500
Alkylnitrile	1382	23:02	104191	720
Tetradecene	1399	23:19	80895	560
Hexadecanoic acid	1427	23:47	455679	3100
Phthalate ester	1433	23:53	441855	3000
$C_{12}H_{28}O$	1494	24:54	347135	2400
Unknown	1507	25:07	107263	740
Octadecanoic acid	1543	25:43	264191	1800
Terphenyl	1565	26:05	211199	1400
Unknown	1600	26:40	268799	1900
C_4-alkylphenanthrene	1612	26:52	154623	1100
Unknown	1654	27:34	325631	2200
Phthalate ester	1671	27:51	195327	1300
N-Propylbenzamide	1738	28:58	94591	650
Unknown	1743	29:03	201471	1400
Unknown	1754	29:14	241919	1700

(continued)

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Table A-25 (concluded)

Tentative Identification	Scan	RT (min)	Area	Yield[b] (µg/g)
Phthalate ester	1777	29:37	1120250	7700
Phthalate ester	1779	29:39	1083390	7500
Phthalate ester	1785	29:45	198911	1400
Unknown	1837	30:37	92159	640
Unknown	1972	32:52	94847	650
Unknown	1977	32:57	189439	1300
Unknown	2065	34:25	178687	1200
Unknown	2067	34:27	169215	1200
Unknown	2088	34:48	143871	990
Unknown	2117	35:17	98431	680

[a]Amount pyrolyzed = 42 µg.

[b]Yield is computed with respect to the mass of the sample pyrolyzed. Product amounts are determined by comparison of their areas with that of an external anthracene standard, assuming relative responses of one. Because of the assumptions implicit in the yield computations, the yield values are only within a factor of five. No internal standard methods or use of authentic standards were used to quantitate the products in this study.

MONS 217654

Table A-26

NOMEX 411 (m-PHENYLENEDIAMINE, ISOPHTHALIC ACID POLYMER)[a], 500°C PYROLYSIS[b]

Tentative Identification	Scan	RT (min)	Area	Yield[c] (µg/g)
Unknown	51	1:27	17535	59
Unknown	82	2:19	29791	100
Tetrachloroethylene	146	4:08	166	0.56
Siloxene	150	4:15	71551	240
Chlorobenzene	169	4:47	5743	19
Unknown	207	5:52	45951	150
Trichloropropane	219	6:12	4815	16
Acetophenone	250	7:05	2695	9.1
Siloxane	272	7:42	21311	72
Dichlorobenzene	282	7:59	6503	22
Alkane	296	8:23	6391	21
Dichlorobenzene	303	8:35	4343	15
Cycloalkane	338	9:35	6327	21
Unknown	347	9:50	7295	24
Siloxane	376	10:39	41151	140
Nonanol	390	11:03	7079	24
Trichlorobenzene	398	11:17	7815	26
Trichlorobenzene	421	11:56	13743	46
Alkane	465	13:10	5287	18
Unknown	470	13:19	4407	15
Siloxane	478	13:33	39295	130
Chloroalkane	504	14:17	3983	13
Cycloalkene	506	14:20	4143	13
Tetrachlorobenzene	517	14:39	12463	42
$C_{14}H_{20}O_2$	561	15:54	13007	44
Siloxane	569	16:07	11087	37
Pentachlorobenzene	592	16:46	12527	42
Alkane	619	17:32	8799	30
Siloxene	649	18:23	2527	8.5
Alkane	664	18:49	7095	24
Hexachlorobenzene	684	19:23	10767	36
Fluorenone	695	19:41	2343	7.9
Siloxane	703	19:55	7271	24
Alkane	707	20:02	2895	9.7
Anthracene	715	20:15	6335	21

(continued)

MONS 217655

Table A-26 (concluded)

Tentative Identification	Scan	RT (min)	Area	Yield[c] (µg/g)
Siloxene	745	21:06	4271	14
Unknown	787	22:18	1305	4.4
Pyrene	830	23:31	1051	3.5

[a]Composition from B. L. Carson, M. D. Erickson, and J. L. McCann (Midwest Research Institute). Literature Review of Pyrolysis and Combustion Products of Selected Utility Materials. Palo Alto, CA: Electric Power Research Institute, November 1985. EPRI EL-4939.

[b]Amount pyrolyzed = 84 µg.

[c]Yield is computed with respect to the mass of the sample pyrolyzed. Product amounts are determined by comparison of their areas with that of an external anthracene standard, assuming relative responses of one. Because of the assumptions implicit in the yield computations, the yield values are only within a factor of five. No internal standard methods or use of authentic standards were used to quantitate the products in this study.

MONS 217656

Table A-27

NOMEX 411 (m-PHENYLENEDIAMINE, ISOPHTHALIC ACID POLYMER)[a], 900°C PYROLYSIS[b]

Tentative Identification	Scan	RT (min)	Area	Yield[c] (µg/g)
Benzene	79	2:14	20639	78
Dimethylhexene	147	4:10	966	3.6
Siloxane	149	4:13	76543	290
Chlorobenzene	169	4:47	19263	72
Unknown	212	6:00	48191	180
Unknown	263	7:27	105599	400
Siloxane	272	7:42	16367	62
Dichlorobenzene	283	8:01	11775	44
Unknown	303	8:35	814	3.1
Dichlorobenzene	305	8:38	11855	45
Siloxane	378	10:43	64255	240
Trichlorobenzene	400	11:20	17055	64
Trichlorobenzene	423	11:59	22591	85
Alkene	467	13:14	10927	41
Siloxane	480	13:36	36799	140
Tetrechlorobenzene	519	14:42	21343	80
Alkane	521	14:46	18527	70
Alkene	572	16:12	31679	120
Unknown	595	6:51	6567	25
Alkane	620	17:34	34943	130
Unknown	623	17:39	14463	54
$C_{15}H_{16}$	640	18:08	8167	31
Alkene	665	18:50	27551	100
Hexachlorobenzene	685	19:24	25791	97
Fluorenone	696	19:43	9263	35
Alkane	708	20:04	15743	59
Unknown	731	20:43	10335	39
Phthalate ester	778	22:03	82431	310
Pyrene	830	23:31	6791	26

[a]Composition from 8. L. Carson, M. D. Erickson, and J. L. McCann (Midwest Research Institute). Literature Review of Pyrolysis and Combustion Products of Selected Utility Materials. Palo Alto, CA: Electric Power Research Institute, November 1986. EPRI EL-4939.

[b]Amount pyrolyzed = 75 µg.

[c]Yield is computed with respect to the mass of the sample pyrolyzed. Product amounts are determined by comparison of their areas with that of an external anthracene standard, assuming relative responses of one. Because of the assumptions implicit in the yield computations, the yield values are only within a factor of five. No internal standard methods or use of authentic standards were used to quantitate the products in this study.

MONS 217657

Table A-28

NOMEX 411 (m-PHENYLENEDIAMINE, ISOPHTHALIC ACID POLYMER)[a], 500°C COMBUSTION[b]

Tentative Identification	Scan	RT (min)	Area	Yield[c] (µg/g)
Unknown	89	2:31	43775	220
Unknown	119	3:22	4543	23
Alkane	129	3:39	6367	33
Unknown	139	3:56	6871	35
Tetrachloroethylene	147	4:10	35455	180
Siloxane	150	4:15	56127	290
Unknown	163	4:37	7015	36
Chlorobenzene	170	4:49	8959	46
Cycloalkane	196	5:33	6543	34
Cycloalkane	200	5:40	5719	29
$C_7H_{14}O$	207	5:52	6111	31
Unknown	215	6:05	17279	89
Chloroalkane	249	7:03	4951	25
Benzaldehyde	252	7:08	6727	34
Unknown	254	7:12	8159	42
Unknown	258	7:19	5207	27
Siloxane	274	7:46	17311	89
Unknown	280	7:56	5855	30
Dichlorobenzene	284	8:03	6183	32
Dichlorobenzene	305	8:38	3583	18
Unknown	328	9:18	2319	12
Unknown	337	9:33	5855	30
Unknown	341	9:40	7871	40
Unknown	349	9:53	16383	84
Unknown	350	9:55	12911	66
Unknown	367	10:24	6319	32
Siloxane	379	10:44	24255	120
Unknown	388	11:00	8351	43
Cycloalkane	392	11:06	26687	140
Trichlorobenzene	401	11:22	16367	84
Unknown	413	11:42	10959	56
Trichlorobenzene	423	11:59	31263	160
Unknown	472	13:22	15007	77
Siloxane	480	13:36	31071	160
Unknown	486	13:46	3963	20
Tetrachlorobenzene	491	13:55	8719	45
Unknown	497	14:05	3743	19
Cycloalkane	508	14:24	11071	57
Tetrachlorobenzene	519	14:42	29375	150
Isoindoledione	559	15:50	4011	21
Dimethylethylcyclohexadienedione	563	15:57	20735	110
Pentachlorobenzene	594	16:50	28287	140
Phthalate ester	622	17:37	22303	110
Hexachlorobenzene	686	19:26	54719	280
Siloxane	704	19:57	7519	39

(continued)

MONS 217658

Table A-28 (concluded)

Tentative Identification	Scan	RT (min)	Area	Yield[c] (µg/g)
Unknown	709	20:05	2067	11
Anthracene	716	20:17	9839	50
Siloxane	747	21:10	2723	14
Unknown	761	21:34	2003	10
Phthalate ester	779	22:04	3091	16
Alkane	789	22:21	1737	8.9
Pyrene	831	23:33	3783	19
Fluoranthene	853	24:1	2451	12
Alkane	904	25:37	1193	6.1

[a]Composition from B. L. Carson, M. D. Erickson, and J. L. McCann (Midwest Research Institute). Literature Review of Pyrolysis and Combustion Products of Selected Utility Materials. Palo Alto, CA: Electric Power Research Institute, November 1986. EPRI EL-4939.

[b]Amount pyrolyzed = 55 µg.

[c]Yield is computed with respect to the mass of the sample pyrolyzed. Product amounts are determined by comparison of their areas with that of an external anthracene standard, assuming relative responses of one. Because of the assumptions implicit in the yield computations, the yield values are only within a factor of five. No internal standard methods or use of authentic standards were used to quantitate the products in this study.

MONS 217659

Table A-29

NOMEX 411 (m-PHENYLENEDIAMINE, ISOPHTHALIC ACID POLYMER)[a], 900°C COMBUSTION[b]

Tentative Identification	Scan	RT (min)	Area	Yield[c] (µg/g)
	59	1:40	323	1.7
Dichlorobenzene	149	4:13	882	4.6
Alkene	160	4:32	746	3.9
Siloxane	169	4:47	1199	6.3
Unknown	184	5:13	3347	18
Unknown	259	7:20	331	1.7
Alkene	289	8:11	1015	5.3
Unknown	311	8:49	4019	21
Siloxane	365	10:20	17279	90
Trichlorobenzene	378	10:43	7711	40
Trichlorobenzene	408	11:34	29279	150
Unknown	471	13:21	4043	21
Siloxane	479	13:34	26431	140
Tetrachlorobenzene	489	13:51	5519	29
Unknown	505	14:18	1349	7.0
Cycloalkane	507	14:22	2639	14
Tetrachlorobenzene	418	14:41	20479	110
Isoindoledione	558	15:49	2323	12
Dimethylethylcyclohexadiene	562	15:55	10911	57
Cycloalkane	568	16:06	1751	9.2
Siloxane	570	16:09	5263	28
Alkane	572	16:12	3543	18
Unknown	583	16:31	2315	12
Pentachlorobenzene	594	16:50	18687	98
Phthelate ester	622	17:37	11919	62
Unknown	666	18:52	1449	7.6
Hexachlorobenzene	685	19:24	11375	60
Fluorenone	697	19:45	3167	16
Siloxane	705	19:58	2535	13
Anthracene	716	20:17	5575	29
Pyrene	831	23:33	2639	14
Fluoranthene	852	24:08	1461	7.6

(continued)

MONS 217660

Table A-29 (concluded)

Tentative Identification	Scan	RT (min)	Area	Yield[c] (µg/g)
Alkane	895	25:21	1193	6.2
Alkane	929	26:19	1767	9.2
Siloxane	1038	29:25	643	3.4

[a]Composition from B. L. Carson, M. D. Erickson, and J. L. McCann (Midwest Research Institute). Literature Review of Pyrolysis and Combustion Products of Selected Utility Materials. Palo Alto, CA: Electric Power Research Institute, November 1986. EPRI EL-4939.

[b]Amount pyrolyzed = 54 µg.

[c]Yield is computed with respect to the mass of the sample pyrolyzed. Product amounts are determined by comparison of their areas with that of an external anthracene standard, assuming relative responses of one. Because of the assumptions implicit in the yield computations, the yield values are only within a factor of five. No internal standard methods or use of authentic standards were used to quantitate the products in this study.

MONS 217661

Table A-30

CREOSOTE, 500°C PYROLYSIS[a]

Tentative Identification	Scan	RT (min)	Area	Yield[b] (µg/g)
Unknown	54	1:32	3767	3.6
Alkene	77	2:11	5751	5.5
Toluene	111	3:09	2051	2.0
Siloxane	141	4:00	8415	8.0
C_2-Alkylbenzene	175	4:57	4327	4.1
$C_{10}H_{18}$	226	6:24	10607	10
C_3-Alkylbenzene	247	7:00	15071	14
Siloxane	270	7:39	14943	14
C_2-Alkylaniline	272	7:42	22623	22
C_3-Alkanylbenzene	315	8:55	50111	48
Unknown	431	12:13	16895	16
Isoquinoline/quinoline	432	12:14	31551	30
Naphthalene	438	12:25	512000	490
Unknown	458	12:59	48511	46
Isoquinoline/quinoline	462	13:05	84095	80
$C_{11}H_{10}$	507	14:22	185599	180
$C_{11}H_{10}$	515	14:35	368639	350
$C_{10}H_{10}$	520	14:44	32095	30
Unknown	522	14:47	33791	32
Unknown	525	14:52	39103	37
Unknown	529	14:59	23967	23
Biphanyl	538	15:15	165119	160
C_2-Alkylnaphthalene	548	15:32	93055	89
C_2-Alkylnaphthalene	556	15:45	89343	85
C_2-Alkylnaphthalene	565	16:00	159743	150
$C_{12}H_{10}$ biphenylene or acenaphthylene	578	16:23	61183	58
Acenaphthene	600	17:00	141311	130
$C_{12}H_{10}$	601	17:02	190975	180
Fluorene	637	18:03	33343	32
Pyrene	650	18:25	14511	14
Unknown	668	18:56	13231	12
Fluoranthene	842	23:51	30079	29
$C_{16}H_{10}$	851	24:07	71423	68
$C_{16}H_{10}$	875	24:47	135679	130
Benzonaphthofuran	879	24:54	71039	68
Benzofluorene	887	25:08	105471	100
$C_{14}H_{10}$	891	25:15	49343	47
Benzofluorene	896	25:23	77951	74
$C_{14}H_{10}$	901	25:32	50623	48
$C_{14}H_{10}$	919	26:02	23519	22
Unknown	978	27:43	12447	12

(continued)

MONS 217662

Table A-30 (concluded)

Tentative Identification	Scan	RT (min)	Area	Yield[b] (µg/g)
$C_{14}H_{10}$	986	27:56	44671	42
Unknown	995	28:11	17151	16
Benzofluoranthene	1088	30:50	50879	48

[a]Amount pyrolyzed = 530 µg.

[b]Yield is computed with respect to the mass of the sample pyrolyzed. Product amounts are determined by comparison of their areas with that of an external anthracene standard, assuming relative responses of one. Because of the assumptions implicit in the yield computations, the yield values are only within a factor of five. No internal standard methods or use of authentic standards were used to quantitate the products in this study.

MONS 217663

Table A-31

CREOSOTE, 900°C PYROLYSIS[a]

Tentative Identification	Scan	RT (min)	Area	Yield[b] (µg/g)
Tetrachloroethene	142	4:01	11679	11
Siloxane	146	4:08	8039	7.6
C_2-Alkylbenzene	175	4:57	9775	9.3
C_3-Alkylbenzene	220	6:14	7143	6.8
Unknown	228	6:28	15103	14
$C_{10}H_{18}$	239	6:46	9423	9.0
Unknown	241	6:50	9439	9.0
C_3-Alkylbenzene	247	7:00	57535	55
C_3-Alkylbenzene	261	7:24	18111	17
Siloxane	269	7:37	8767	8.3
C_3-Alkylbenzene	271	7:41	42751	41
Benzofuran	274	7:46	60543	58
Unknown	293	8:18	24639	23
$C_{10}H_{18}$	297	8:25	28607	27
Unknown	450	12:45	83199	79
Unknown	455	12:53	66047	63
Isoquinoline or Quinoline	459	13:00	95231	91
Dihydrobenzothiophene	465	13:10	21311	20
Unknown	471	13:21	21087	20
Unknown	480	13:36	29023	28
Unknown	501	14:12	153855	150
$C_{11}H_{10}$	504	14:17	210431	200
Methylbenzothiophene	506	14:20	36351	35
$C_{11}H_{10}$	511	14:29	153855	150
$C_{11}H_{10}$	513	14:32	257535	240
Alkene	519	14:42	55103	52
Unknown	522	14:47	49791	47
Biphenyl	536	15:11	195327	180
C_2-Alkylnaphthalene	545	15:26	114047	110
C_2-elkylnephthelene	553	15:40	120063	110
C_2-elkylnaphthalene	562	15:55	207871	200
Unknown	565	16:00	48063	46
Biphenylene or Acenephthylene	574	16:16	114047	110
Alkene	582	16:29	71295	68
$C_{12}H_{10}$	601	17:02	390655	370
$C_{16}H_{12}$	794	22:30	4127	3.9

(continued)

MONS 217664

Table A-31 (concluded)

Tentative Identification	Scan	RT (min)	Area	Yield[b] (µg/g)
$C_{10}H_{14}$ (unresolved)	700-1200	19:50-34:00	-	
$C_{16}H_{10}$	832	23:34	31807	30
$C_{16}H_{10}$	853	24:10	32383	31

[a]Amount pyrolyzed = 530 µg.

[b]Yield is computed with respect to the mass of the sample pyrolyzed. Product amounts are determined by comparison of their areas with that of an external anthracene standard, assuming relative responses of one. Because of the assumptions implicit in the yield computations, the yield values are only within a factor of five. No internal standard methods or use of authentic standards were used to quantitate the products in this study.

Table A-32

CREOSOTE, 500°C COMBUSTION[a]

Tentative Identification	Scan	RT (min)	Area	Yield[b] (µg/g)
$C_{10}H_{16}$	81	2:18	5135	4.9
C_3-Alkylbenzene	143	4:03	25151	24
C_3-Alkylbenene	155	4:23	9519	9.1
C_3-Alkylbenzene	171	4:51	5543	5.3
C_3-Alkylbenzene	193	6:28	10319	9.8
Benzofuren	196	5:33	10383	9.9
Unknown	239	6:46	13439	13
C_9H_{10}	250	7:05	38207	36
Benzonitrile	277	7:51	2403	2.3
Dichlorobenzene	291	8:15	10127	9.6
C_9H_{10}	299	8:28	17215	16
C_9H_{10}	312	8:50	91903	88
$C_{10}H_{12}$	345	9:46	39935	38
$C_{10}H_8$	412	11:40	200000	190
Unknown	420	11:54	2347	2.2
Nephthalene	434	12:18	549888	520
Benzothiophene	450	12:45	84479	80
Unknown	455	12:53	57983	55
Isoquinoline or Quinoline	461	13:04	152575	140
$C_{11}H_{14}$	467	13:14	29407	28
$C_{11}H_{10}$	502	14:13	205055	200
Unknown	504	14:17	21951	21
Methylnephthalene	511	14:29	268799	260
Biphenyl	535	15:09	203007	190
Unknown	538	15:15	27551	26
C_2-Alkylnephthelene	544	15:25	102655	98
C_2-Alkylnephthalene	551	15:37	142079	140
C_2-Alkylnephthelene	563	15:57	128767	120
Biphenylene or Acenaphthylene	574	16:16	111743	110
Acenephthene	605	17:08	301567	290
Oibenzofuran	623	17:39	264191	250
Fluorene	653	18:30	84351	80
$C_{13}H_{12}$	655	18:33	100607	96
Methyldibenzofuran	672	19:02	136959	130
Methylfluorene	693	19:38	78847	75
Unknown	708	20:04	54911	52
Anthracene	757	21:27	350000	330
Unknown	760	21:32	30495	29
$C_{16}H_{12}$	764	21:39	49343	47
$C_{13}H_{10}$	788	22:20	43135	41
Unknown	794	22:30	9567	9.1
2-Phenylnaphthelene	802	22:43	40191	9.1
C_2-Alkylphenanthrene	808	22:54	5559	38

(continued)

MONS 217666

Table A-32 (concluded)

Tentative Identification	Scan	RT (min)	Area	Yield[b] (µg/g)
Pyrene	840	23:48	67583	5.3
Fluoranthene	859	24:20	45759	64
$C_{14}H_{10}$	757-1200	21:27-34:00	-	-

[a]Amount pyrolyzed = 530 µg.

[b]Yield is computed with respact to the mass of the sample pyrolyzed. Product amounts ere determined by comparison of their areas with thet of an extarnal anthracene standard, assuming relative responses of one. Because of the assumptions implicit in the yield computations, the yield values are only within a factor of five. No internel standard methods or use of authentic standards were used to quantitate the products in this study.

MONS 217667

Table A-33

CREOSOTE, 900°C COMBUSTION[a]

Tentetive Identification	Scan	RT (min)	Area	Yield[b] (µg/g)
Unknown	60	1:42	2647	2.5
Unknown	72	2:02	7031	6.7
Unknown	80	2:16	877	0.84
Tetrachloroethene	135	3:49	5119	4.9
Siloxene	140	3:58	8639	8.2
Chlorobenzene	160	4:32	610	0.58
Unknown	214	6:04	4319	4.1
C_3-Alkylbenzene	245	6:56	5815	5.5
Unknown	266	7:32	4135	3.9
Siloxane	268	7:36	11711	11
C_3-Alkylpyridine	273	7:44	13823	13
Unknown	275	7:47	9103	8.7
Cycloalkene	294	8:20	4879	4.6
Naphthalene	431	12:13	541000	520
Benzothiophene	443	12:33	91903	88
Isoquinoline or Quinoline	456	12:55	140287	130
Unknown	458	12:59	24959	24
Unknown	490	13:53	388	0.37
$C_{11}H_{10}$	497	14:05	205055	200
$C_{11}H_{10}$	506	14:20	243199	230
Methylquinoline	516	14:37	65343	62
Biphenyl	532	15:04	152063	140
C_2-Alkylnaphthalene	540	15:18	118399	110
C_2-Alkylnaphthalene	547	15:30	155903	150
Unknown	549	15:33	26143	25
C_2-Alkylnaphthalene	558	15:49	127487	120
C_2-Alkylnaphthalene	564	15:59	127871	120
$C_{12}H_8$ biphenylene or acenaphthylene	570	16:09	138751	130
C_2-Alkylnaphthalene	572	16:12	77439	74
Unknown	592	16:46	35519	34
$C_{12}H_{10}$	596	6:53	297983	280
Unknown	598	16:57	74751	71
Unknown	613	17:22	177919	170
Fluorene	639	18:06	128127	120
Methylbiphenyl	648	18:22	71039	68
Methyldibenzofuran	655	18:33	54079	51
Methyldibenzofuran	663	18:47	84351	80
Methyldibenzofuran	667	18:54	25983	25
Unknown	679	19:14	24159	23

(continued)

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Table A-33 (concluded)

Tentative Identification	Scan	RT (min)	Area	Yield[b] (µg/g)
$C_{14}H_{12}$	690	19:33	46463	44
$C_{14}H_{10}$	721	20:26	45055	43
$C_{14}H_{10}$	738-1200	20:55-34:00	-	

[a]Amount pyrolyzed = 530 µg.

[b]Yield is computed with respect to the mass of the sample pyrolyzed. Product amounts are determined by comparison of their areas with that of an external anthracene standard, assuming ralative responses of one. Because of the assumptions implicit in the yield computations, the yield values are only within a factor of five. No internal standard methods or use of authentic standards were used to quantitate the products in this study.

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Table A-34

MAPLE WOOD, 500°C PYROLYSIS[a]

Tentative Identification	Scan	RT (min)	Area	Yield[b] (µg/g)
Styrene	288	4:48	12575	76
Acetic acid	295	4:55	204287	1,200
Methoxymethyl pentanone	313	5:13	279551	1,700
Unknown	353	5:53	40831	250
Pentadienenitrile	378	6:18	45759	280
Unknown	387	6:27	66431	400
Dihydropyren	546	9:06	140287	850
Benzaldehyde	584	9:44	75007	450
Siloxane	586	9:46	48255	290
Acetylcyclohexene	722	12:02	108159	650
Nonanal	728	12:08	110975	670
Methoxymethylphenol	803	13:23	46399	280
Alkane	810	13:30	124927	760
Octanoic acid	814	13:34	78975	480
Benzoic acid	821	13:41	64767	390
Methoxymethylphenol	826	13:46	81407	490
Alkene	904	15:04	225279	1,400
Alkane	910	15:10	205311	1,200
Hydroxymethylphenylethanone	944	15:44	143615	870
Dimethoxyphenol	980	16:20	237823	1,400
Decanoic acid	986	16:26	142335	860
Alkene	993	16:33	148735	900
Biphenyl	1008	16:48	56319	340
Trimethoxybenzene	1060	17:40	217087	1,300
Trimethoxybenzene	1061	17:41	204287	1,200
Methoxypropenylphenol	1063	17:43	126335	760
Alkene	1076	17:56	127103	770
Alkane	1082	18:02	326655	2,000
Unknown	1094	18:14	29503	180
Unknown	1123	18:43	49663	300
Unknown	1154	19:14	157183	950
Alkene	1156	19:16	494079	3,000
Unknown	1158	19:18	166911	1,000
Alkane	1161	19:21	176383	1,100
Unknown	1170	19:30	178431	1,100
Phthalate ester	1178	19:38	73855	450
Dimethoxypropenylphenol	1184	19:44	67967	410
Tetradecanoic acid, methyl ester	1256	20:56	18847	110
Dimethoxypropenylphenol	1260	21:00	265727	1,600
Unknown	1291	21:31	280575	1,700
Tetradecanoic acid	1296	21:36	484863	2,900
Unknown	1298	21:38	2167	13
Alkene	1302	21:42	362495	2,200
Siloxane	1333	22:13	34559	210
Dodecanoic acid	1356	22:36	151551	920
Alkene	1367	22:47	545791	3,300

(continued)

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Table A-34 (concluded)

Tentative Identification	Scan	RT (min)	Area	Yield[b] (µg/g)
Unknown	1392	23:12	90623	550
Hexadecanoic acid	1429	23:49	612351	3,700
Phthalate ester	1433	23:53	311807	1,900
Unknown	1447	24:07	81279	490
Unknown	1461	24:21	38719	230
Alkene	1485	24:45	223743	1,400
Alkene	1495	24:55	512511	3,100
Unknown	1510	25:10	120447	730
Unknown	1545	25:45	326143	2,000
Siloxane	1600	26:40	250879	1,500
Siloxane	1651	27:31	291839	1,800
Siloxane	1653	27:33	323071	2,000
Unknown	1671	27:51	173567	1,100
C_8-Alkyloctahydrophenanthrene carboxylic acid	1675	27:55	108031	650
Unknown	1743	29:03	153343	930
Unknown	1756	29:16	326655	2,000
Phthalate ester	1775	29:35	427519	2,600
Phthalate ester	1785	29:45	85375	520
Unknown	1834	30:34	61567	370
Unknown	1927	32:07	33983	210
Siloxane	1972	32:52	47103	290
Siloxane	1973	32:53	48191	290
Siloxane	2066	34:26	176639	1,100
Siloxane	2067	34:27	164607	1,000
Siloxane	2088	34:48	122751	740

[a]Amount pyrolyzed = 45 µg.

[b]Yield is computed with respect to the mass of the sample pyrolyzed. Product amounts are determined by comparison of their areas with that of an external anthracene standard, assuming relative responses of one. Because of the assumptions implicit in the yield computations, the yield values are only within a factor of five. No internal standard methods or use of authentic standards were used to quantitate the products in this study.

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Table A-35

MAPLE WOOD, 900°C PYROLYSIS[a]

Tentative Identification	Scan	RT (min)	Area	Yield[b] (µg/g)
Dichloroethylene	120	2:00	92031	240
Methylfuran	151	2:31	104703	270
Benzene	202	3:22	767999	2,000
Dimethylfuran	233	3:53	20191	52
Toluene	309	5:09	499199	1,300
C_8H_{16} Alkene	328	5:28	281087	720
Alkane	338	5:38	164095	420
Siloxene	365	6:05	87552	220
Siloxane	377	6:17	43199	110
Chlorobenzene	411	6:51	70783	180
C_2 Alkylbenzene	429	7:09	172543	440
C_2 Alkylbenzene	442	7:22	250367	640
C_2 Alkylbenzene	453	7:33	146175	380
Styrene	471	7:51	461823	1,200
C_8H_8	488	8:08	767999	2,000
C_3 Alkenylbenzene	551	9:11	243967	630
Propylbenzene	560	9:20	74623	190
C_3 Alkylbenzene	571	9:31	87807	230
Benzaldehyde	577	9:37	204543	530
Siloxane	591	9:51	74623	190
Methylstyrene	595	9:55	541695	1,400
Methylstyrene	606	10:06	79615	200
Phenol	608	10:08	85759	220
Unknown	614	10:14	134655	350
Methylstyrene	646	10:46	262655	670
Indene	674	11:14	556031	1,400
Hydroxymethylcyclopenteneone	678	11:18	106879	270
Acetophenone	698	11:38	245759	630
$C_{11}H_{22}$ Alkene	705	11:45	311295	800
Alkane	713	11:53	437759	1,100
Cresol	715	11:55	136447	350
Unknown	725	12:05	157183	400
C_4 Alkylbenzene	735	12:15	49407	130
Methylbenzofuran	740	12:20	30463	78
Unknown	759	12:39	97791	250
C_4 Alkadienylbenzene	785	13:05	250367	640
$C_{10}H_{10}$	791	13:11	113407	290
Methyleneindene	796	13:16	75135	190
$C_{10}H_{10}$	803	13:23	108799	280
Alkene	808	13:28	370175	950
Alkane	815	13:35	161279	410
Naphthalene	827	13:47	414719	1,100
Benzoic acid	832	13:52	69119	180
Alkane	903	15:03	295935	760
Alkane	909	15:09	373247	960
Nonanoic acid	915	15:15	142335	370
Siloxane	924	15:24	77311	200

(continued)

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Table A-35 (concluded)

Tentative Identification	Scan	RT (min)	Area	Yield[b] (µg/g)
Dimethoxyphenol	985	16:25	220927	570
Unknown	993	16:33	115071	300
Alkene	995	16:35	389631	1,000
Alkane	999	16:39	266239	680
Biphenyl	1013	16:53	605183	1,600
$C_{13}H_{12}$	1024	17:04	135679	350
$C_{13}H_{12}$	1053	17:33	92415	240
Eugenol	1066	17:46	218879	560
Alkene	1076	17:56	376319	970
Alkane	1082	18:02	500223	1,300
Methylbiphenyl	1097	18:17	232703	600
Methylbiphenyl	1106	18:26	134143	340
Unknown	1108	18:28	78207	200
Dodecanoic acid	1155	19:15	300543	770
Alkene	1157	19:17	503807	1,300
Unknown	1159	19:19	195583	500
Alkane	1161	19:21	519167	1,300
Unknown	1174	19:34	466431	1,200
Fluorene	1191	19:51	586751	1,500
Unknown	1220	20:20	146687	380
Alkene	1229	20:29	231679	600
Alkane	1234	20:34	303615	780
Hydroxydimethoxybenzaldehyde	1242	20:42	121855	310
Methoxy eugenol	1262	21:02	233471	600
Alkadiene	1290	21:30	73855	190
Tetradecanoic acid	1298	21:38	274431	700
Alkene	1301	21:41	257279	660
Alkane	1305	21:45	249599	640
$C_{14}H_{10}O$	1341	22:21	237567	610
Heptadecanol	1366	22:46	414207	1,100
Hexadecanoic acid	1429	23:49	445439	1,100
Phthalate	1432	23:52	351231	900
Unknown	1484	24:44	207103	530
$C_{12}H_{26}O$-Alcohol	1494	24:54	365567	940
Octadecenoic acid	1543	25:43	222719	570
Siloxene	1600	26:40	283647	730
Siloxane	1652	27:32	258559	660
Unknown	1733	28:53	84479	220
Unknown	1753	29:13	194559	500
Diisooctyl phthalate	1773	29:33	478207	1,200
Unknown	1778	29:38	68863	180
Unknown	1835	30:35	58175	150

[a]Amount pyrolyzed = 110 µg.

[b]Yield is computed with respect to the mass of the sample pyrolyzed. Product amounts are determined by comparison of their areas with that of an external anthracene standard, assuming relative responses of one. Because of the assumptions implicit in the yield computations, the yield values are only within a factor of five. No internal standard methods or use of authentic standards were used to quantitate the products in this study.

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Table A-36

MAPLE WOOD, 500°C COMBUSTION[a]

Tentative Identification	Scan	RT (min)	Area	Yield[b] (µg/g)
Unknown	109	1:49	259583	860
Unknown	121	2:01	190463	630
Benzene	143	2:23	494591	1,600
Alkane	151	2:31	488959	1,600
C_6H_8	177	2:57	244223	810
Siloxane	246	4:06	7775	26
Toluene	251	4:11	79615	260
Furancarboxaldehyde	285	4:45	232959	770
Furancarboxaldehyde	348	5:48	168447	560
Styrene	409	6:49	121855	400
Heptanal	421	7:01	232959	770
Benzaldehyde	522	8:42	340991	1,100
Unknown	524	8:44	45119	150
C_3-Alkenylbenzene	537	8:57	17599	58
Unknown	550	9:10	411647	1,400
Benzonitrile	554	9:14	57983	190
Chlorophenol	562	9:22	28671	95
Octenal	567	9:27	291839	970
Phenol	596	9:56	326655	1,100
Unknown	601	10:01	29855	99
Hydroxybenzaldehyde	633	10:33	175615	580
Unknown	658	10:58	99455	330
Unknown	663	11:03	136959	450
Chloroalkane	669	11:09	65087	220
Unknown	678	11:18	106623	350
C_3-Alkenylbenzene	682	11:22	102143	340
Methylbenzaldehyde	682	11:22		
Benzoic acid, methyl ester	695	11:35	53951	180
Nonanal	697	11:37	437759	1,500
Benzenecarbothioic acid	741	12:21	44287	150
Unknown	752	12:32	179967	600
Unknown	789	13:09	111103	370
2-Decenone	799	13:19	75263	250
Unknown	805	13:25	79871	270
Decanal	812	13:32	377343	1,300
Benzoic acid	816	13:36	32287	110
Unknown	842	14:02	50943	170
Alkene	873	14:33	141567	470
Alkene	893	14:53	81151	270
Unknown	902	15:02	158207	530
Undecanal	916	15:16	464383	1,500
Dihydroindenone	923	15:23	70911	240
Unknown	933	15:33	52671	180
Decanoic acid	985	16:25	100479	330
Biphenyl	1003	16:43	254719	850
Dodecenal	1009	16:49	343039	1,100

(continued)

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Table A-36 (concluded)

Tentative Identification	Scan	RT (min)	Area	Yield[b] (µg/g)
Hydroxymethoxybenzaldehyde	1036	17:16	100863	330
Tridecanal	1095	18:15	368639	1,200
Alkene	1153	19:13	447999	1,500
Unknown	1162	19:22	148223	490
Unknown	1166	19:26	146175	490
Alkyl propanoate	1170	19:30	285183	950
Unknown	1174	19:34	316927	1,100
Diethyl phthalate	1176	19:36	68991	230
Hydroxydimethoxybenzaldehyde	1237	20:37	222463	740
Alkene aldehyde	1249	20:49	267775	890
Tetradecanoic acid	1289	21:29	413695	1,400
Alkene	1297	21:37	233727	780
Tetradecanal	1320	22:00	407039	1,400
Alkene	1363	22:43	499199	1,700
Tetradecanenitrile	1379	22:59	69631	230
Alkene	1395	23:15	78591	260
Hexadecanoic acid	1420	23:40	398847	1,300
Phthalate ester	1429	23:49	503295	1,700
Unknown	1480	24:40	119935	400
Unknown	1490	24:50	383999	1,300
Unknown	1503	25:03	59967	200
Unknown	1505	25:05	69247	230
Unknown	1513	25:13	64511	210
Alkene	1518	25:18	71679	240
Unknown	1534	25:34	72575	240
Siloxane	1595	26:35	153343	510
Unknown	1604	26:44	70911	240
Tetramethylphenanthrene	1607	26:47	85631	280
Unknown	1643	27:23	152063	510
Unknown	1659	27:39	92031	310
Unknown	1718	28:38	46783	160
Unknown	1742	29:02	143615	480
Dioctylphthalate	1762	29:22	206335	690
Unknown	1820	30:20	22879	76
Unknown	1958	32:38	7375	24
Siloxane	2048	34:08	71935	240
Siloxane	2069	34:29	40383	130

[a]Amount pyrolyzed = 82 µg.

[b]Yield is computed with respect to the mass of the sample pyrolyzed. Product amounts are determined by comparison of their areas with that of an external anthracene standard, assuming relative responses of one. Because of the assumptions implicit in the yield computations, the yield values are only within a factor of five. No internal standard methods or use of authentic standards were used to quantitate the products in this study.

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Table A-37

MAPLE WOOD, 900°C COMBUSTION[a]

Tentative Identification	Scan	RT (min)	Area	Yield[b] (µg/g)
Unknown	81	1:21	2635	12
Alkene	117	1:57	166655	730
Unknown	118	1:58	193791	850
Dichloroethene	123	2:03	58879	260
Acetic acid, methyl ester	126	2:06	26111	110
Unknown	147	2:27	162815	720
Methylfuran	153	2:33	44863	200
Benzene	196	3:16	532479	2,300
Alkane	211	3:31	254719	1,100
Alkane	219	3:39	245247	1,100
Alkane	220	3:40	251647	1,100
Unknown	328	5:28	257791	1,100
Unknown	345	5:45	217343	950
Hexanal	361	6:01	88191	390
Furancarboxaldehyde	399	6:39	144895	640
Chlorobenzene	411	6:51	45503	200
Chlorobenzene	421	7:01	136703	600
Unknown	468	7:48	48319	210
Styrene	470	7:50	29407	130
C_8H_8	479	7:59	133375	590
Heptanal	491	8:11	217343	950
Unknown	555	9:15	108927	480
Benzaldehyde	575	9:35	366591	1,600
Siloxane	590	9:50	13695	60
Unknown	592	9:52	84863	370
Phenol	601	10:01	154879	680
Octanal	614	10:14	339455	1,500
Unknown	643	10:43	49087	220
Hydroxybenzaldehyde	671	11:11	72319	320
Acetophenone	696	11:36	82431	360
Phenylalkanone	697	11:37	105087	460
Nonanal	725	12:05	328703	1,400
Unknown	755	12:35	105343	460
Unknown	790	13:10	23487	100
Unknown	806	13:26	79487	350
Alkene	807	13:27	70655	310
Alkyl ketone	814	13:34	67199	300
Methylphenylethanone	821	13:41	57087	250
Naphthalene	825	13:45	46399	200
Decanal	827	13:47	255443	1,100
Trichlorobenzene	853	14:13	21407	94
C_8-Alkylbenzene	856	14:16	28223	120
C_8-Alkenone	862	14:22	82303	360
C_8-Alkanone	863	14:23	79103	350
Alkene	883	14:43	58239	260

(continued)

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Table A-37 (concluded)

Tentative Identification	Scan	RT (min)	Area	Yield[b] (µg/g)
Nonanoic acid	898	14:48	91775	400
Undecanal	923	15:23	333311	1,500
Dimethoxyphenol	979	16:19	123519	540
Biphenyl	1008	16:48	290815	1,300
Dodecanal	1013	16:53	184575	810
Hydroxymethoxybenzaldehyde	1031	17:11	69631	310
Alkene	1076	17:56	82175	360
Tridecanal	1097	18:17	197375	870
Hydroxybiphenyl	1127	18:47	20255	89
Dibenzofuran	1132	18:52	77439	340
Dodecenoic acid	1147	19:07	257023	1,100
Alkene	1155	19:15	191999	840
Unknown	1159	19:19	107903	470
Alkyl propanoate ester	1171	19:31	110207	480
Unknown	1176	19:36	220927	970
Hydroxydimethoxybenzaldehyde	1233	20:33	81919	360
Tetradecanal	1251	20:51	150783	660
Tetradecanoicacid	1286	21:26	195583	860
Alkene	1300	21:40	139519	610
Alkylaldehyde	1322	22:02	192255	840
Alkene	1364	22:44	292351	1,300
Alkanoic acid	1415	23:35	82559	360
Phthalate ester	1429	23:49	327167	1,400
Alkene	1483	24:43	63871	280
Alkanoic acid ester	1493	24:53	168703	740
Unknown	1495	24:55	2009	8.8
Siloxane	1596	26:36	24223	110
Siloxane	1647	27:27	67327	300
Unknown	1670	27:50	18463	81
Unknown	1749	29:09	50687	220
Phthalate ester	1770	29:30	56703	250
Unknown	1968	32:48	8991	39
Siloxane	2059	34:19	22655	100
Unknown	2081	34:41	10959	48

[a]Amount pyrolyzed = 62 µg.

[b]Yield is computed with respect to the mass of the sample pyrolyzed. Product amounts are determined by comparison of their areas with that of an external anthracene standard, assuming relative responses of one. Because of the assumptions implicit in the yield computations, the yield values are only within a factor of five. No internal standard methods or use of authentic standards were used to quantitate the products in this study.

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Table A-38

KRAFT PAPER (TOR-2), 500°C PYROLYSIS[a]

Tentative Identification	Scan	RT (min)	Area	Yield[b] (µg/g)
Unknown	112	1:52	54719	590
Dichloroethene	118	1:58	52991	570
Unknown	127	2:07	55679	600
2,3-Butanedione	141	2:21	45887	500
Methylfuren	147	2:27	29823	320
Methylfuran	157	2:37	15951	170
Benzene	188	3:08	407551	4400
C_8H_8	206	3:26	295423	3200
Dimethylfuran	226	3:46	6207	67
Dimethylfuran	245	4:05	11855	130
Acetic acid	306	5:06	157183	1700
Unknown	324	5:24	189439	2000
Siloxane	359	5:59	15295	160
Siloxane	373	6:13	26431	290
Furancarboxaldehyde	393	6:33	100223	1100
Unknown	405	6:45	18559	200
Unknown	410	6:50	31391	340
Unknown	413	6:53	2111	23
Unknown	440	7:20	6759	73
Unknown	465	7:45	20575	220
Unknown	475	7:55	29919	320
Unknown	485	8:05	20607	320
Unknown	527	8:47	12239	220
Methylbutenal	552	9:12	61311	130
Methylfurancarboxaldehyde	562	9:22	14527	660
Benzaldehyde	569	9:29	31583	340
Siloxene	586	9:46	38591	420
Unknown	607	10:07	36159	390
Unknown	639	10:39	30495	330
Hydroxymethylcyclopentenone	668	11:08	54079	590
Alkene	706	11:46	52159	560
Unknown	723	1:03	52671	570
Siloxene	753	12:33	58559	640
Unknown	778	12:58	12463	140
Alkene	808	13:28	77311	840
Unknown	820	13:40	19903	220
Unknown	855	14:15	24127	260
Unknown	901	15:01	88959	960
Siloxane	916	15:16	45119	490
Hydroxymethylphenylethanone	938	15:38	11535	120
Decenoic acid	979	16:19	42943	460
Alkene	983	16:23	36095	390
Unknown	985	16:25	14495	160
Siloxane	1064	17:44	32095	350
Alkene	1067	17:47	44927	490
Alkane	1072	17:52	100223	1100

(continued)

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Table A-38 (concluded)

Tentative Identification	Scan	RT (min)	Area	Yield[b] (µg/g)
Dodecanoic acid	1141	19:01	116863	1300
Alkene	1145	19:05	121471	1300
Alkane	1150	19:10	105983	1100
Dimethylbenzenebutenoic acid	1155	19:15	73983	800
Siloxane	1193	19:53	22527	240
$C_{15}H_{16}$	1196	19:56	135423	1500
Alkane	1222	20:22	87039	940
Unknown	1239	20:39	15535	170
Tetradecanoic acid	1279	21:19	142847	1500
Alkene	1289	21:29	145919	1600
Tetradecenal	1311	21:51	111487	1200
Unknown	1323	22:03	19999	220
Pentadecanoic acid	1342	22:22	63615	690
Alkene	1353	22:33	169215	1800
Alkylnitrile	1368	22:48	23519	260
Hexadecanoic acid	1411	23:31	226303	2400
Phthalate ester	1419	23:39	189439	2000
Unknown	1429	23:49	47295	510
Alkylaldehyde	1441	24:01	50687	550
Unknown	1471	24:31	46911	510
Alkene	1479	24:39	123007	1300
Alkene	1480	24:40	151295	1600
Unknown	1495	24:55	36543	400
Unknown	1518	25:18	19359	210
Octadecanoic acid	1526	25:26	95871	1000
Alkene	1539	25:39	24543	270
Unknown	1561	26:01	23583	260
Siloxane	1585	26:25	126847	1400
Unknown	1605	26:45	20607	220
Siloxene	1637	27:17	173055	1900
Dioctyl edipate	1657	27:37	35775	390
Unknown	1706	28:26	12511	140
Unknown	1722	28:42	15983	170
Unknown	1735	28:55	21087	230
Phthelate ester	1755	29:15	66559	720
Unknown	1766	29:26	7519	82
Unknown	1806	30:06	4263	46
Unknown	1817	30:17	5000	54
Unknown	1826	30:26	4383	48
Siloxane	2033	33:53	23103	250
Siloxane	2054	34:14	10575	110

[a]Amount pyrolyzed = 96 µg.

[b]Yield is computed with respect to the mass of the sample pyrolyzed. Product amounts are determined by comparison of their areas with that of an external anthracene standard, assuming relative responses of one. Because of the assumptions implicit in the yield computations, the yield values are only within a factor of five. No internal standard methods or use of authentic standards were used to quantitate the products in this study.

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Table A-39

KRAFT PAPER (TOR-2), 900°C PYROLYSIS[a]

Tentative Identification	Scan	RT (min)	Area	Yield[b] (ug/g)
Unknown	122	2:02	59199	640
Benzene	198	3:18	167935	1800
C_6H_6	227	3:47	124799	1400
Toluene	331	5:31	189439	2100
Alkene	350	5:50	46399	500
Siloxene	383	6:23	23359	250
Chlorobenzene	426	7:06	42431	460
C_2-Alkylbenzene	444	7:24	62143	670
C_2-Alkylbenzene	453	7:33	44223	480
Unknown	466	7:46	22303	240
Styrene	485	8:05	200703	2200
C_3-Alkenylbenzene	547	9:07	36159	390
C_3-Alkylbenzene	566	9:26	16047	170
Benzaldehyde	572	9:32	45823	500
Siloxene	587	9:47	18143	200
C_3-Alkenylbenzene	590	9:50	113407	1200
C_3-Alkenylbenzene	601	10:01	11615	130
C_3-Alkenylbenzene	609	10:09	35967	390
C_3-Alkenylbenzene	641	10:41	36543	400
Indene	668	11:08	114815	1200
Acetophenone	692	11:32	39935	430
Cycloalkane	700	11:40	76671	830
Alkene	708	11:48	87423	950
Nonenal	719	11:59	19775	210
Siloxene	754	12:34	19103	210
Methylindene	779	12:59	48447	520
Alkene	802	13:22	78463	850
Alkene	809	13:29	43711	470
Nephthelene	821	13:41	79103	860
Unknown	890	14:50	2279	25
Alkene	897	14:57	61119	660
Alkene	903	15:03	70655	770
Methylnaphthalene	926	15:26	28159	310
Methylnephthalene	944	15:44	26303	280
Alkene	987	16:27	118015	1300
Biphenyl	1005	16:45	164351	1800
Siloxane	1066	17:46	20767	230
Alkene	1070	17:50	90623	980
Alkene	1075	17:55	134399	1500
Unknown	1100	18:20	10751	120
Alkene	1149	19:09	138495	1500
Alkane	1154	19:14	123647	1300
Dimethylbenzenebutanoic acid	1167	19:27	76159	830
Fluorene	1183	19:43	120959	1300
$C_{15}H_{16}$	1200	20:00	55871	610
Alkene	1227	20:27	110463	1200

(continued)

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Table A-39 (concluded)

Tentative Identification	Scan	RT (min)	Area	Yield[b] (µg/g)
Tetradecanoic acid	1289	21:29	94463	1000
Alkene	1294	21:34	128127	1400
Alkane	1298	21:38	102783	1100
Tetradecanal	1316	21:56	47999	520
Anthracene	1334	22:14	40703	440
Unknown	1349	22:29	50879	550
Alkene	1359	22:39	135679	1500
Alkene nitrile	1374	22:54	31423	340
Unknown	1384	23:04	15295	170
Unknown	1419	23:39	111231	1200
Phthelate ester	1424	23:44	136959	1500
Alkene	1487	24:47	115071	1200
Unknown	1500	25:00	31103	340
Octadecenoic acid	1534	25:34	71167	770
Unknown	1548	25:48	3007	33
Siloxane	1592	26:32	90111	980
Unknown	1613	26:53	38335	420
Siloxane	1645	27:25	101759	1100
Alkane	1655	27:35	38847	420
Unknown	1665	27:45	20639	220
Unknown	1713	28:33	42815	460
Unknown	1729	28:49	57599	620
Unknown	1742	29:02	60031	650
Phthalate aster	1762	29:22	195583	2100
Unknown	1767	29:27	31135	340
Unknown	1778	29:38	18655	200
Alkane	1840	30:40	44735	490
Unknown	1862	31:02	13167	140
Alkane	1915	31:55	45887	500
Unknown	1953	32:33	25567	280
Alkane	2001	33:21	53055	570
Siloxana	2042	34:02	53055	580
Siloxane	2066	34:26	30527	330
Alkane	2122	35:22	26783	290

[a]Amount pyrolyzed = 96 µg.

[b]Yield is computed with respect to the mass of the sample pyrolyzed. Product amounts are determined by comparison of their areas with that of an external anthracene standard, assuming relative responses of one. Because of the assumptions implicit in the yield computations, the yield values are only within a factor of five. No internal standard methods or use of authentic standards were used to quantitate the products in this study.

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Table A-40

KRAFT PAPER (TOR-2), 500°C COMBUSTION[a]

Tentative Identification	Scan	RT (min)	Area	Yield[b] (µg/g)
Unknown	77	1.17	13951	200
Unknown	110	1:50	50367	730
Benzene	185	3:05	151551	2200
Benzene	192	3:12	45055	650
Benzene	211	3:31	107519	1600
Pentenone	308	5:08	40127	580
Acetic acid	343	5:43	70655	1000
Unknown	359	5:59	111743	1600
Siloxane	375	6:15	16639	240
Unknown	382	6:22	8039	120
Furancarboxaldehyde	391	6:31	23679	340
Furancarboxaldehyde	419	6:49	42495	610
Styrene	476	7:56	32063	460
Heptenal	487	8:07	44095	640
Benzeldehyde	558	9:18	20575	300
Benzeldehyde	571	9:31	106495	1500
Unknown	586	9:46	13247	190
Phenol/benzonitrile	599	9:59	42559	620
Phenol	610	10:10	59583	860
Hydroxybenzaldehyde	665	11:05	27039	390
Acetophenone	691	11:31	37375	540
Nonanel	719	11:59	85887	1200
Siloxane	752	12:32	20671	300
Alkene	800	13:20	20095	290
Decanel	821	13:41	67583	980
Unknown	849	14:09	10047	140
Unknown	895	14:55	27455	400
Undecanal	917	15:17	76031	1100
Decanoic ecid	977	16:17	28607	410
Biphenyl	1000	16:40	88447	1300
Benzopyranone	1069	17:49	8415	120
Tridecanal	1089	18:09	70911	1000
Dodecanoic acid	1140	19:00	81279	1200
Alkene	1147	19:07	61695	890
Dimethylbenzenebutenoic acid	1154	19:14	35839	520
Tetradecanal	1169	19:29	62143	900
$C_{15}H_{1e}$	1199	19:59	73087	1100
$C_{15}H_{1e}$	1224	20:24	39103	560
Alkane aldehyde	1243	20:43	58175	840
Tetradecanoic acid	1280	21:20	71807	1000
Alkene	1292	21:32	61183	880
Fluorenone	1302	21:42	31007	450
Hexadecanal	1314	21:54	89215	1300
Pentadecanoic acid	1344	22:24	22591	330
Hexadecanoic acid	1412	23:32	105727	1500
Phthalate ester	1423	23:43	143871	2100

(continued)

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Table A-40 (concluded)

Tentative Identification	Scan	RT (min)	Area	Yield[b] (µg/g)
Unknown	1485	24:45	58623	850
Unknown	1510	25:10	1519	22
Octadecanoic acid	1530	25:30	36223	520
Unknown	1549	25:49	10703	150
Siloxane	1589	26:29	71039	1000
Unknown	1600	26:40	20895	300
Unknown	1610	26:50	22591	330
Unknown	1628	27:08	10543	150
Siloxane	1641	27:21	106111	1500
Unknown	1662	27:42	24607	360
Unknown	1682	28:02	6767	98
Unknown	1700	28:20	15167	220
Unknown	1727	28:47	24511	350
Unknown	1740	29:00	62527	900
Phthalate ester	1760	29:20	34687	500
Siloxane	1951	32:31	16047	230
Siloxane	1952	32:32	15119	220
Siloxane	2040	34:00	51135	740
Siloxane	2061	34:21	30335	440
Siloxane	2091	34:51	15855	230

[a]Amount pyrolyzed = 72 µg.

[b]Yield is computed with respect to the mass of the sample pyrolyzed. Product amounts are determined by comperison of their erees with that of en external anthracene standard, assuming relative responses of one. Because of the essumptions implicit in the yield computations, the yield velues ere only within a factor of five. No internal standard methods or use of euthentic standards were used to quantitete the products in this study.

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Table A-41

KRAFT PAPER (TOR-2), 900°C COMBUSTION[a]

Tentative Identification	Scan	RT (min)	Area	Yield[b] (µg/g)
Unknown	144	2:24	103423	1600
Unknown	154	2:34	8111	120
Unknown	176	2:56	49983	750
Benzene	223	3:43	142335	2100
Toluene	325	5:25	274943	4100
Unknown	347	5:47	27807	420
Siloxane	378	6:18	23039	350
Chlorobenzene	422	7:02	73727	1100
C_2-Alkylbenzene	439	7:19	60799	920
Styrene	477	7:57	152831	2300
C_8H_8	481	8:01	137983	2100
C_3-Alkenylbenzene	546	9:06	18239	280
Benzaldehyde	576	9:36	143103	2200
C_3-Alkenylbenzene	586	9:49	45375	680
Phenol	596	9:56	23647	360
Benzofuren	613	10:13	95615	1400
C_3-Alkenylbenzene	641	10:41	25087	380
C_3-Alkenylbenzene	667	11:07	84351	1300
Methylphenol	673	11:13	27487	400
Acetophenone	694	11:34	88959	1300
Unknown	699	11:39	28543	430
Methylbenzeldehyde	709	11:49	18239	280
Nonanol	720	12:00	60543	900
Methylbenzofuran	735	12:15	20607	310
Unknown	758	12:38	16575	250
$C_{10}H_{10}$	779	12:59	23615	360
Unknown	787	13:07	14719	220
Dihydronaphthalene	797	13:17	24159	360
Naphthelene	822	13:42	157695	2400
Trichlorobenzene	847	14:07	19135	290
Unknown	893	14:53	19967	300
Unknown	917	15:17	51135	770
Dihydroindenone	920	15:20	24247	360
Methylnaphthalene	943	15:43	30591	460
Unknown	975	16:15	32127	480
Biphenyl	1008	16:48	179967	2700
Methylenebenzene	1045	17:25	24095	360
Methylbiphenyl	1089	18:09	57407	860
Dibenzofuran	1127	18:47	142847	2200
Dodecanoic acid	1138	18:58	69375	1000
Alkene	1148	19:08	63103	950
Dimethylbenzenebutanoic acid	1152	19:12	33727	510
Phthelete ester	1169	19:29	33599	510
Fluorene	1180	19:40	73471	1100
Diphenylethene	1188	19:48	23455	350
$C_{15}H_{16}$	1199	19:59	49471	750

(continued)

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Table A-41 (concluded)

Tentative Identification	Scan	RT (min)	Area	Yield[b] (µg/g)
Benzophenone	1209	20:09	27647	420
Unknown	1216	20:16	21055	320
$C_{15}H_{16}$	1224	20:24	27199	410
Unknown	1232	20:32	12175	180
Methyldibenzofuran	1256	20:56	12687	190
$C_{14}H_{12}$	1265	21:05	19839	300
Tetradecanoic acid	1279	21:19	61055	920
Alkene	1293	21:33	46591	700
Fluorenone	1302	21:42	117247	1800
Anthrecene	1332	22:12	106495	1600
Alkene	1357	22:37	52223	790
C_2-Alkenylenthrecene	1377	22:57	16703	250
Terphenyl	1392	23:12	14927	220
Hexadecanoic acid	1412	23:32	89855	1400
Phthalate ester	1423	23:43	132095	2000
Phenylnaphthalene	1453	24:13	30207	460
Unknown	1485	24:45	39615	600
Unknown	1500	25:00	14959	220
Unknown	1530	25:30	40639	610
Terphenyl	1555	25:55	64127	970
Terphenyl	1581	26:21	29631	450
Siloxane	1590	26:30	73855	1100
Unknown	1611	26:51	29279	440
Phthalate ester	1627	27:07	16479	250
Siloxane	1642	27:22	104575	1600
$C_{21}H_{30}O_2$	1663	27:43	28319	430
Unknown	1672	27:52	12719	190
Unknown	1685	28:05	17919	270
Unknown	1741	29:01	95103	1400
Phthalate ester	1761	29:21	55359	830
Unknown	1952	32:32	19999	301
Siloxane	2042	34:02	53887	810
Siloxane	2062	34:22	40255	610
Siloxane	2092	34:52	19391	290

[a]Amount pyrolyzed = 69 µg.

[b]Yield is computed with respect to the mass of the sample pyrolyzed. Product amounts are determined by comparison of their areas with that of an external anthracene standard, assuming relative responses of one. Because of the assumptions implicit in the yield computations, the yield values are only within a factor of five. No internal standard methods or use of authentic standards were used to quantitate the products in this study.

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Table A-42

RAG PAPER (TOR-3), 900°C PYROLYSIS

Tentative Identification	Scan	RT (min)	Area
Unknown	72	1:12	70784
Unknown	82	1:22	27104
Methylfuran	86	1:26	167423
C_8H_8	94	1:34	26048
Benzene	100	1:40	72704
Unknown	110	1:50	29728
Unknown	116	1:56	52224
Unknown	121	2:01	46016
Methylfuran	140	2:20	70144
Toluene	145	2:25	52736
Methylbutenal	156	2:36	37248
Unknown	165	2:45	22944
Siloxane	181	3:01	55936
Cresol	186	3:06	28000
Methylfuran	207	3:27	57152
Methylfuran	218	3:38	85760
Methylfuranone	225	3:45	24992
Xylene	236	3:56	17152
Methylcyclopentenone	253	4:13	33856
Unknown	257	4:17	19168
Furanylethanone	267	4:27	42112
Benzeldehyde	292	4:52	24832
Unknown	316	5:16	18464
Unknown ester	322	5:22	41536
Methylcyclopentenone	326	5:26	25695
Unknown	334	5:34	38976
Unknown	341	5:41	14080
Methylstyrene	347	5:47	4976
Phenol	360	6:00	24352
Indene	364	6:04	17024
C_8H_{14}	376	6:16	14560
Hydroxymethylcyclopentenone	402	6:42	36352
Unknown	436	7:16	6816
Unknown	446	7:26	27008
Methylindene	459	7:39	18048
Unknown	467	7:47	30784
Unknown	475	7:55	22784
Xylenol	480	8:00	14832
Unknown	498	8:18	5856
Unknown	545	9:05	11296
Unknown	560	9:20	22560
Unknown	584	9:44	16112
Unknown	590	9:50	16608
Siloxane	618	10:18	29792
Unknown	625	10:25	17408
Unknown	648	10:48	12144

(continued)

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Table A-42 (concludad)

Tentative Identification	Scan	RT (min)	Area
Hydroxymethylfurfural	654	10:54	8832
Dimethylnaphthalene	664	11:04	5176
Unknown	669	11:09	4504
Eugenol	710	11:50	8864
Unknown	723	12:03	5104
Alkane	729	12:09	6488
Unknown	754	12:34	12592
Unknown	775	12:55	9040
Octanone	800	13:20	8800
Unknown	804	13:24	5488
Unknown	876	14:36	11952
Unknown	909	15:09	9184
Hexadecanoic acid	1037	17:17	24416
Octadecanoic acid	1147	19:07	16112

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Table A-43

KRAFT PRESSBOARD (TOR-5), 900°C PYROLYSIS

Tentative Identification	Scan	RT (min)	Area
Unknown	72	1:12	61824
Unknown	83	1:23	16832
Unknown	87	1:27	107136
Methylfuran	88	1:28	75392
Cyclohexadiene	95	1:35	29664
Benzene	101	1:41	74752
Unknown	102	1:42	77056
Methylpentene	107	1:47	11968
Methylbutenal	111	1:51	30432
Methylpentanone	115	1:55	24992
Unknown	117	1:57	55808
Unknown	122	2:02	55040
Unknown	125	2:05	14944
Methylpentene	135	2:15	15264
Methylfuran	142	2:22	61568
Unknown	143	2:23	25344
Toluene	147	2:27	61056
Methylbutenal	157	2:37	34112
Methylbutenal	164	2:44	16672
Unknown	167	2:47	22560
Unknown	180	3:00	52736
Siloxene	183	3:03	62592
Cresol	188	3:08	28928
Unknown	205	3:25	78720
Methylfuran	218	3:38	94080
Unknown	219	3:38	
Unknown	224	3:44	32896
Xylene	235	3:55	21568
Unknown	245	4:05	18368
Bicyclo[3.1.0]hexanone	251	4:11	41280
Methylfurancarboxaldehyde	256	4:16	13056
Bicyclo[3.1.0]hexanone	261	4:21	20896
Unknown	261	4:21	
Tetramethylcyclobutene	265	4:25	33792
Unknown	274	4:34	9520
Unknown	280	4:40	11632
Acetophenone	291	4:51	24896
Benzaldehyde	291	4:51	
Methylfurfurel	312	5:12	39808
Unknown	312	5:12	
Unknown	316	5:16	33728
Unknown	318	5:18	36480
Unknown	339	5:39	23072
Phenol	353	5:53	46656
C_3 Alkynylbenzene	362	6:02	20864
Unknown	374	6:14	18720

(continued)

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Table A-43 (concluded)

Tentative Identification	Scan	RT (min)	Area
Unknown	381	6:21	large
Unknown	397	6:37	20032
Mathylbenzofuran	419	6:59	15104
Cresol	425	7:05	12384
Cresol	404	6:44	18240
Unknown	431	7:11	23264
Unknown	447	7:27	30848
Methylindene	459	7:39	21984
Siloxane	459	7:39	
Unknown	467	7:47	19872
Unknown	476	7:56	40320
Hydroxymethylpyranone	495	8:15	19808
Ethylbenzenediol	506	8:26	30496
Dimethylbenzofuran	511	8:31	10144
Unknown	546	9:06	14880
Unknown	555	9:15	17440
Methylnaphthalene	578	9:38	16080
Unknown	586	9:46	9488
Unknown	591	9:51	14928
Siloxane	601	10:01	8208
Methoxymethylbutane	621	10:21	38400
Silane	648	10:48	13072
Eugenol	711	11:51	16672
Unknown	801	13:21	7816
Silane	877	14:37	14272
Unknown	905	15:05	8208
Hexadecanoic acid	1038	17:18	20448

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Table A-44

35 KV CABLE-CPE INSULATION, 500°C PYROLYSIS[a]

Tentative Identification	Scan	RT (min)	Area	Yield[b] (µg/g)
Methylfuran	152	2:32	29183	180
Siloxane	366	6:06	101503	620
Siloxane	376	6:16	40639	250
Siloxane	592	9:52	47167	290
Alkane	714	11:54	127359	780
Siloxane	720	12:00	28543	180
Benzoic acid	821	13:41	26591	160
Unknown	904	15:04	129407	800
Alkene	910	15:10	121855	750
Unknown	914	15:14	39167	240
Cycloalkane	993	16:33	121215	740
Alkane	1077	17:57	127103	780
Alkene	1082	18:02	256255	1600
Alkene	1156	19:16	364031	2200
Alkene	1161	19:21	185343	1100
Dimethylbenzenebutenoic acid	1170	19:30	106879	650
Tetradecanoic acid	1295	21:35	233727	1400
Alkene	1302	21:42	332799	2000
Alkane	1306	21:46	166911	1000
Pentedecanoic acid	1356	22:36	122367	750
Alkene	1367	22:47	373759	2300
Hexadecanoic acid	1426	23:46	319487	2000
Phthelate ester	1431	23:51	85503	520
Unknown	1485	24:45	126335	770
Alkene	1495	24:55	392703	2400
Siloxane	1600	26:40	226815	1400
Siloxene	1650	27:30	255487	1600
Siloxane	1653	27:33	274943	1700
Phthalate ester	1772	29:32	82303	500
Siloxane	2050	34:10	79359	490

[a]Amount pyrolyzed = 46 µg.

[b]Yield is computed with respect to the mass of the sample pyrolyzed. Product amounts are determined by comperison of their areas with that of an external anthrecene standard, assuming relative responses of one. Because of the assumptions implicit in the yield computations, the yield values are only within a factor of five. No internal standard methods or use of authentic standards were used to quantitete the products in this study.

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Table A-45

35 KV CABLE-CPE INSULATION, 900°C PYROLYSIS[a]

Tentative Identification	Scan	RT (min)	Area	Yield[b] (µg/g)
Styrene	483	8:03	1020920	1800
Unknown	485	8:05	548863	9700
Unknown	489	8:09	114431	2000
C_8H_8	494	8:14	519167	9100
C_2-Alkylbenzene	496	8:16	66559	1200
Methylpropenylcyclopentane	499	8:19	150527	2700
C_7H_{12}	503	8:23	45183	800
Unknown	513	8:33	78975	1400
C_3-Alkenylbenzene	547	9:07	100479	1800
C_3-Alkylbenzene	556	9:16	159487	2800
C_3-Alkenylbenzene	558	9:18	207359	3700
Ethylcycloheptatriene	566	9:26	141567	2500
C_3-Alkylbenzene	577	9:37	53887	950
Benzaldehyde	582	9:42	232574	4100
Unknown	584	9:44	114559	2000
C_3-Alkenylbenzene	591	9:51	102015	1800
Alkenol	594	9:54	787455	14000
C_3-Alkenylbenzene	601	10:01	365567	6400
Alkene	605	10:05	775167	14000
Unknown	610	10:10	83711	1500
Alkene	613	10:13	574463	10000
Unknown	618	10:18	209919	3700
C_3-Alkenylbenzene	622	10:22	147199	2600
C_3-Alkenylbenzene	652	10:52	201983	3600
Unknown	654	10:54	46079	810
C_3-Alkenylbenzene	666	11:06	134399	2400
C_3-Alkynylbenzene	670	11:10	72063	1300
C_4-Alkenylbenzene	672	11:12	127999	2300
1H-Indene	679	11:19	617471	11000
(2-Propenyloxy)methylbenzene	683	11:23	95615	1700
Methylphenol	685	11:25	107903	1900
Unknown	696	11:36	102271	1800
Unknown	704	11:44	628735	11000
Unknown	706	11:46	96895	1700
Alkene	713	11:53	897023	16000
Alkane	722	12:02	569343	10000
Unknown	731	12:11	211967	3700
Alkane	735	12:15	88831	1600
Dimethylphenol	742	12:22	48703	860
Methylbenzofuran	746	12:26	46911	830
Alkene	788	13:08	112511	2000
C_4-Alkadienylbenzene	790	13:10	296959	5200
C_4-Alkedienylbenzene	796	13:16	143871	2500
Naphthelene	800	13:20	127487	2200
Alkadiene	806	13:26	791551	14000
Methylindene	808	13:28	146943	2600

(continued)

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Table A-45 (concluded)

Tentative Identification	Scan	RT (min)	Area	Yield[b] (µg/g)
Alkene	815	13:35	106700	1900
Alkane	821	13:41	855039	15000
Alkene	825	13:45	79359	1400
$C_{10}H_8$	832	13:52	500223	8800
Alkadiene	901	15:01	510463	9000
Alkene	910	15:10	573791	10000
Alkane	916	15:16	508927	9000
Unknown	919	15:19	64191	1100
Dihydroindenone	929	15:29	91135	1600
Methylnaphthalene	937	15:37	214271	3800
Ethylidenaindene	955	15:55	220159	3900
Alkadiene	993	16:33	542719	9600
Alkene	1000	16:40	930815	16000
Alkane	1005	16:45	454143	8000
Biphenyl	1015	16:55	711679	13000
Methylbiphenyl	1028	17:08	122495	2200
Alkadiene	1075	17:55	527359	9300
Alkene	1083	18:03	884735	16000
Alkenol	1095	18:15	76799	1400
Methylbiphenyl	1100	18:20	182015	3200
Methylbiphenyl	1109	18:29	108287	1900
Cycloalkene	1157	19:17	348671	6100
Alkene	1163	19:23	612351	11000
Alkane	1167	19:27	448511	7900
Cycloalkene	1175	19:35	55039	9700
Alkylpropanoic acid ester	1179	19:39	195071	3400
Phthalate ester	1182	19:42	78335	1400

[a]Amount pyrolyzed = 33 µg.

[b]Yield is computed with respect to the mass of the sample pyrolyzed. Product amounts are determined by comparison of their areas with that of an external anthracene standard, assuming relative responses of one. Because of the assumptions implicit in the yield computations, the yield values are only within a factor of five. No internal standard methods or use of authentic standards were used to quantitate the products in this study.

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Table A-46

35 KV CABLE-CPE INSULATION, 500°C COMBUSTION[a]

Tentative Identification	Scan	RT (min)	Area	Yield[b] (µg/g)
Unknown	160	2:40	199423	1800
Benzene	201	3:21	413695	3800
C_6H_6	217	3:37	396287	3600
Toluene	310	5:10	60607	550
Chlorobenzene	430	7:10	68479	620
Styrene	486	8:06	194559	1800
Heptenal	498	8:18	305151	2800
Benzaldehyde	581	9:41	340479	3100
C_3-Alkenylbenzene	596	9:56	175359	1600
Unknown	619	10:19	336895	3100
Hydroxybenzaldehyde	674	11:14	92287	840
Unknown	695	11:35	96383	880
Acetophenone	701	11:41	212735	1900
Cycloalkane	707	11:47	209151	1900
Unknown	715	11:55	243711	2200
Nonanal	729	12:09	477695	4300
Unknown	794	13:14	43007	390
Alkene	809	13:29	166399	1500
Alkane	816	13:36	192255	1700
Octanoic acid	824	13:44	118271	1100
Decanal	831	13:51	428543	3900
Cycloalkane	904	15:04	115455	1000
Unknown	913	15:13	210687	1900
Undecanal	926	15:26	449023	4100
Unknown	993	16:33	314879	2900
Biphenyl	1010	16:50	280575	2500
Dodecanal	1015	15:55	263579	2400
Cycloalkane	1077	17:57	183551	1700
Dibenzofuran	1133	18:53	54911	500
Alkene	1156	19:16	294399	2700
Unknown	1158	19:18	92159	840
Dimethylbenzenebutanoic acid	1172	19:32	121983	1100
Tetradecanoic acid	1297	21:37	268287	2400
Alkene	1302	21:42	188415	1700
Alkene	1368	22:48	349183	3200
Hexadecanoic acid	1429	23:49	335871	3000
Phthelate ester	1434	23:54	327167	2969
Alkene	1495	24:55	447999	4100
Alkanol	1523	25:23	114559	1000
Octadecanoic acid	1544	25:44	185087	1680
Siloxane	1600	26:40	216831	2000
C_3-Alkylphenanthrene	1613	26:53	196607	1800
Siloxane	1651	27:31	308223	2800
Siloxane	1653	27:33	265215	2400
Phthalate ester	1672	27:52	164351	1500
Unknown	1756	29:16	231423	2100

(continued)

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Table A-46 (concluded)

Tentative Identification	Scan	RT (min)	Area	Yield[b] (µg/g)
Phthalate ester	1775	29:35	340479	3100
Unknown	2067	34:27	201471	1800
Unknown	2088	34:48	122111	1100

[a]Amount pyrolyzed = 31 µg.

[b]Yield is computed with respect to the mass of the sample pyrolyzed. Product amounts are determined by comparison of their areas with that of an external anthracene standard, assuming relative responses of one. Because of the assumptions implicit in the yield computations, the yield values are only within a factor of five. No internal standard methods or use of authentic standards were used to quantitete the products in this study.

MONS 217694

Table A-47

35 KV CABLE-CPE INSULATION, 900°C COMBUSTION[a]

Tentative Identification	Scan	RT (min)	Area	Yield[b] (µg/g)
Benzene	195	3:15	312831	1400
Siloxane	366	6:06	47551	220
Siloxene	383	6:23	57151	260
Chlorobenzene	430	7:10	43455	200
Heptanal	497	8:17	293887	1300
Unknown	565	9:25	148735	670
Benzaldehyde	577	9:37	120575	550
C_8-Alkenylbenzene	595	9:55	56895	260
Phenol	605	10:05	103423	470
Unknown	618	10:18	354303	1600
Unknown	693	11:33	115199	520
Acetophenone	698	11:38	61567	280
Alkane	714	11:54	204799	930
Nonanal	728	12:08	515583	2300
Alkane	816	13:36	248063	1100
Methylacetophenone	823	13:43	87039	400
Decanal	831	13:51	421887	1900
Unknown	885	14:45	94975	430
Alkanoic acid	909	15:09	77311	350
Alkane	911	15:11	207359	940
Undecanal	926	15:26	543743	2500
Alkane	999	16:39	181503	820
Dodecanal	1015	16:55	541695	2500
Cycloalkane	1077	17:57	119167	540
Alkane	1083	18:03	219391	1000
Tridecanal	1100	18:20	497663	2300
Dodecanoic acid	1152	19:12	277503	1300
Alkene	1157	19:17	172543	780
Alkane	1162	19:22	263167	1200
Dimethylbenzenebutanoic acid	1167	19:27	172287	780
Tetradecanal/Phthalate ester	1179	19:39	314367	1400
Alkane	1236	20:36	267775	1200
Tetradecanoic acid	1292	21:32	221439	1000
Alkene	1302	21:42	187903	850
Alkane	1306	21:46	233215	1100
Alkene	1368	22:48	305151	1400
Alkane	1373	22:53	204287	930
Alkane	1389	23:09	87167	400
Hexadecanoic acid	1422	23:42	181247	820
Phthalate ester	1433	23:53	411135	1900
Unknown	1455	24:15	72319	330
Alkane	1497	24:57	258815	1200
Unknown	1519	25:19	86527	390
Siloxane	1650	27:30	93183	420
Phthalate ester	1670	27:50	100863	460
Triphenyl phosphate	1707	28:27	30751	140

(continued)

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Table A-47 (concluded)

Tentative Identification	Scan	RT (min)	Area	Yield[b] (µg/g)
Unknown	1753	29:13	79615	360
Phthelate ester	1774	29:34	178943	810
Siloxane	2064	34:24	104319	470
Siloxane	2086	34:46	57919	260

[a]Amount pyrolyzed = 62 µg.

[b]Yield is computed with respect to the mass of the sample pyrolyzed. Product amounts are determined by comparison of their areas with that of an external anthracene standard, assuming relative responses of one. Because of the assumptions implicit in the yield computations, the yield values are only within a factor of five. No internal standard methods or use of authentic standards were used to quantitate the products in this study.

MONS 217696

Table A-48

MIDEL 7131 (PENTAERYTHRITOL ALIPHATIC AND AROMATIC ESTERS)[a], 500°C PYROLYSIS[b]

Tentative Identification	Scan	RT (min)	Area	Yield[c] (µg/g)
Methylfuran	149	2:29	60607	20
Benzene	188	3:08	179711	60
Tetrachlorodifluoroethane	195	3:15	42623	14
Tetrachlorodifluoroethane	221	3:41	48575	16
Tetrachloroethylene	322	5:22	400895	130
Dichlorobutene	377	6:17	160767	53
Dichlorobutane	415	6:55	358399	120
Ethylbenzene	427	7:07	26751	8.9
Xylene	432	7:12	30943	10
Styrene	466	7:46	57919	19
Heptanal	479	7:59	290303	97
7Methylcycloheptene	532	8:52	235775	78
Dimethylheptyne	556	9:16	265727	88
C_3-Alkylbenzene	564	9:24	38079	13
Heptanenitrile	580	9:40	165887	55
Octanone	590	9:50	475135	160
C_3-Alkylbenzene	596	9:56	69375	23
Unknown	603	10:03	190463	63
Methyl heptanoate	627	10:27	611327	200
Trimethylbicycloheptane	639	10:39	180991	60
C_3-Alkylphenol	643	10:43	134911	45
Octahydroindene	645	10:45	115711	38
C_3-Alkylcyclohexene	663	11:03	82815	28
Unknown	668	11:08	114559	38
Unknown	674	11:14	211455	70
Trimethylcyclopentenone	680	11:20	132095	44
Unknown	689	11:29	199423	66
Methyl undecenoate	695	11:35	139775	46
Unknown	703	11:43	321535	110
Methyl octanoate	734	12:14	273919	91
Unknown	759	12:39	51071	17
C_4-Alkenylbenzene	763	12:43	31935	11
Dihydronaphthalene	774	12:54	27455	9.1
Unknown	867	14:27	143871	48
Unknown	879	14:39	151551	50
Tridecene	895	14:55	276991	92
Unknown	901	15:01	34751	12
Alkane	903	15:03	176127	59
Unknown	916	15:16	144127	48
Nonanoic acid	925	15:25	72191	24
Unknown	928	15:28	65407	22
Tridecanone	1069	17:49	606207	400
Unknown	1081	18:01	169727	110
Unknown	1086	18:06	456703	300
Unknown	1095	18:15	198143	130

(continued)

MONS 217697

Table A-48 (concluded)

Tentative Identification	Scan	RT (min)	Area	Yield[c] (µg/g)
Unknown	1111	18:31	291839	190
Unknown	1118	18:38	165631	110
Unknown	1121	18:41	70783	47
Unknown	1129	18:49	127999	85
Unknown	1134	18:54	127871	85
Methylundecanone	1144	19:04	561151	370
Unknown	1160	19:20	139007	92
Unknown	1185	19:45	101375	67
C_3-Alkylbiphenyl	1204	20:04	471551	310
Pentadecanone	1215	20:15	89983	60
C_3-Alkylbiphenyl	1228	20:28	330239	220
Chloroalkane	1356	22:36	56191	37
Alkane	1470	24:30	142847	95
Unknown	1474	24:34	306687	200
Alkane	1482	24:42	38783	26
Unknown	1489	24:49	47167	31
Unknown	1496	24:56	55103	37
Unknown	1500	25:00	121983	81
Unknown	1509	25:09	79103	53
Unknown	1530	25:30	71167	47

[a]Composition from B. L. Carson, M. D. Erickson, and J. L. McCenn (Midwest Research Institute). Literature Review of Pyrolysis and Combustion Products of Selected Utility Materials. Palo Alto, CA: Electric Power Research Institute. November 1986. EPRI EL-4939.

[b]Amount pyrolyzed = 1 mg.

[c]Yield is computed with respect to the mass of the sample pyrolyzed. Product amounts are determined by comparison of their areas with that of an external anthracene standerd, assuming relative responses of one. Because of the assumptions implicit in the yield computations, the yield values are only within a factor of five. No internal standard methods or use of authentic standards were used to quantitate the products in this study.

Table A-49

MIDEL 7131 (PENTAERYTHRITOL ALIPHATIC AND AROMATIC ESTERS)[a], 900°C PYROLYSIS[b]

Tentative Identification	Scan	RT (min)	Area	Yield[c] (µg/g)
Benzene	182	3:02	401919	130
Toluene	315	5:15	279551	93
Tetrachloroethylene	349	5:49	45567	15
Ethylbenzene	435	7:15	71295	24
Xylene	445	7:25	175103	58
Xylene	476	7:56	99967	33
Unknown	549	9:09	44351	15
Siloxane	582	9:42	59199	20
Alkyl ketone	584	9:44	132095	44
Alkyl ketone	593	9:53	336383	110
C_3-Alkylbenzene	598	9:58	116735	39
Methylheptanoate	627	10:27	194303	65
Methylpropylidene cyclopentane	638	10:38	78335	26
Unknown	646	10:46	62143	21
Indene	662	11:02	101375	34
C_4-Alkylbenzene	667	11:07	38591	13
Unknown	675	11:15	88447	29
Unknown	690	11:30	141055	47
Nonanone	700	11:40	263167	88
Nonanone	706	11:46	468991	160
C_4-Alkylbenzene	727	12:07	33983	11
Unknown	734	12:14	82559	27
Methyl octanoate	736	12:16	232191	77
Siloxane	751	12:31	77695	26
C_4-Alkenylbenzene	764	12:44	67327	22
Unknown	770	12:50	75903	25
C_4-Alkenylbenzene	777	12:57	176383	59
C_4-Alkenylbenzene	784	13:04	103295	34
Unknown	929	15:29	132095	44
Unknown	931	15:31	51903	17
Benzoic acid	948	15:48	74495	25
Unknown	960	16:00	70399	23
Nonanoic acid	968	16:08	182015	61
Tridecanone	1082	18:02	606207	200
Unknown	1098	18:18	255231	85
Unknown	1107	18:27	199935	66
C_6-Alkylphenol	1118	18:38	91263	30
Unknown	1121	18:41	325119	110
Dodecanoic acid	1143	19:03	156415	52
Unknown	1182	19:42	89471	30
Fluorene	1186	19:46	107903	36
C_3-Alkylbiphenyl	1201	20:01	271871	90
Pentadecenone	1210	20:10	91263	30
C_3-Alkylbiphenyl	1224	20:24	156159	52

(continued)

MONS 217699

Table A-49 (concluded)

Tentative Identification	Scan	RT (min)	Area	Yield[c] (µg/g)
Unknown	1460	24:20	81919	27
Unknown	1465	24:25	197119	66
Alkane	1491	24:51	75263	25
Siloxane	1623	27:03	20895	6.9

[a]Composition from B. L. Carson, M. O. Erickson, and J. L. McCann (Midwest Research Institute). Literature Review of Pyrolysis and Combustion Products of Selected Utility Materials. Palo Alto, CA: Electric Power Research Institute. November 1986. EPRI EL-4939.

[b]Amount pyrolyzed = 1 mg.

[c]Yield is computed with respect to the mass of the sample pyrolyzed. Product amounts are determined by comparison of their areas with that of an external anthracene standard, assuming relative responses of one. Because of the assumptions implicit in the yield computations, the yield values are only within a factor of five. No internal standard methods or use of authentic standards were used to quantitate the products in this study.

MONS 217700

Table A-50

MIOEL 7131 (PENTAERYTHRITOL ALIPHATIC AND AROMATIC ESTERS)[a], 500°C COMBUSTION[b]

Tentative Identification	Scan	RT (min)	Area	Yield[c] (µg/g)
Unknown	97	1:37	238591	79
Acetic acid	168	2:48	129535	43
Benzene	193	3:13	138751	46
Unknown	306	5:06	145407	48
Acetic acid anhydride	333	5:33	324095	110
Tetrachloroethylene	355	5:55	32767	11
Siloxane	363	6:03	25311	8.4
Dichlorobutene	410	6:50	68991	23
Heptanal	478	7:58	74495	25
Unknown	560	9:20	172543	57
C_8-Alkene	599	9:59	106751	35
Methylcyclopentenone	604	10:04	203519	68
Phenol	610	10:10	211199	70
Methyl heptenoate	630	10:30	114047	38
Methylphenol	683	11:23	50623	17
Unknown	693	11:33	61439	20
Siloxene	716	11:56	23583	7.8
Unknown	908	15:08	64447	21
Unknown	936	15:36	147967	49
Unknown	938	15:38	67199	22
Benzoic acid	954	15:54	223743	74
Unknown	966	16:06	52991	18
Alkenoic acid	973	16:13	158207	53
Tridecanone	1085	18:05	241151	80
Alkyl ketone	1102	18:22	381439	130
Unknown	1130	18:50	166399	55
Unknown	1141	19:01	98815	33
Alkyl ketone	1153	19:13	228863	76
Unknown	1169	19:29	79743	27
C_3-Alkylbiphenyl	1212	20:12	604159	200
C_3-Alkylbiphenyl	1234	20:34	564223	190
Unknown	1468	24:28	99071	33

(continued)

MONS 217701

Table A-50 (concluded)

Tentative Identification	Scan	RT (min)	Area	Yield[c] (µg/g)
Alkyl ketone	1472	24:32	192767	64
Unknown	1498	24:58	78079	26
Unknown	1507	25:07	43839	15

[a]Composition from B. L. Carson, M. O. Erickson, and J. L. McCann (Midwest Research Institute). Literature Review of Pyrolysis and Combustion Products of Selected Utility Materials. Palo Alto, CA: Electric Power Research Institute, November 1986. EPRI EL-4939.

[b]Amount pyrolyzed = 1 mg.

[c]Yield is computed with respect to the mass of the sample pyrolyzed. Product amounts are determined by comparison of their areas with that of an external anthracene standard, assuming relative responses of one. Because of the assumptions implicit in the yield computations, the yield values are only within a factor of five. No internal standard methods or use of authentic standards were used to quantitate the products in this study.

MONS 217702

Table A-51

WEMCOL FLUID (ISOPROPYLBIPHENYL)[a], 500°C PYROLYSIS[b]

Tentative Identification	Scan	RT (min)	Area	Yield[c] (µg/g)
Benzene	160	2:40	473599	140
C_8H_8	182	3:02	219903	65
Toluene	290	4:50	87039	26
Siloxene	378	6:18	42495	13
Styrene	557	9:17	65279	19
C_3-Alkenylbenzene	687	11:27	44287	13
C_3-Alkylbenzene	703	11:43	102271	30
C_3-Alkenylbenzene	709	11:49	18463	5.5
C_4-Alkenylbenzene	808	13:28	29919	8.8
Alkene	810	13:30	173823	51
C_4-Alkylbenzene	833	13:53	30943	9.1
C_4-Alkylbenzene	838	13:58	95999	28
Methylindene	866	14:26	49151	14
Alkene	962	16:02	112895	33
Biphenyl	1045	17:25	330239	98
Dimethylfluorene	1194	19:54	99071	29
Unknown	1198	19:58	105599	31
C_2-Alkylbiphenyl[d]	1201	20:01	89471	26
C_3-Alkylbiphenyl[d]	1289	21:29	180223	53
C_3-Alkenylbiphenyl	1295	21:35	340479	100
Unknown	1300	21:40	154111	46
C_4-Alkylbiphenyl	1305	21:45	414207	122
Unknown	1307	21:47	290303	86
C_4-Alkylbiphenyl	1311	21:51	176383	52
C_3-Alkenylbiphenyl	1315	21:55	275455	81
C_3-Alkenylbiphenyl	1317	21:57	395263	117
C_4-Alkylbiphenyl	1321	22:01	84095	25
C_4-Alkylbiphenyl	1329	22:09	33087	9.8
$C_{14}H_{10}$	1334	22:14	491007	145
Fluorenone	1339	22:19	48511	14
Biphenylylethanone	1356	22:36	70143	21
Biphenylylethanone	1377	22:57	48639	14

[a]Composition from J. V. Zbozinek, J. R. Marsh, D. Guth, and A. Bohrnerud (SCS Engineers, Inc.). State-of-the-Art Review of Combustion and Pyrolysis By-Products of PCB Substitutes. Palo Alto, CA: Electric Power Research Institute, March 1986. EPRI EL-4503.

[b]Amount pyrolyzed = 980 µg.

[c]Yield is computed with respect to the mass of the sample pyrolyzed. Product amounts are determined by comparison of their areas with that of an external anthracene standard, assuming relative responses of one. Because of the assumptions implicit in the yield computations, the yield values are only within a factor of five. No internal standard methods or use of authentic standards were used to quantitate the products in this study.

[d]Major component of Wemcol, overloaded peak. Quantitation unreliable.

MONS 217703

Table A-52

WEMCOL FLUID (ISOPROPYLBIPHENYL)[a], 500°C COMBUSTION[b]

Tentative Identification	Scan	RT (min)	Area	Yield[c] (µg/g)
Benzene	167	2:47	465407	82
C_6H_6	175	2:55	102271	18
Unknown	284	4:44	318975	57
Benzaldehyde	566	9:26	37759	6.7
C_3-Alkenylbenzene	581	9:41	43327	7.7
Nonanal	722	12:02	202239	36
Decanal	826	13:46	159231	28
Trichlorobenzene	851	14:11	57535	10
Biphenyl	1009	16:49	291327	52
Unknown	1272	21:12	159487	28
Unknown	1295	21:35	65663	12
Unknown	1297	21:37	62015	11
C_3-Alkenylbiphenyl	1300	21:40	391167	69
C_3-Alkylbiphenyl[d]	1303	21:43	171263	30
Unknown	1310	21:50	257791	46
Unknown	1313	21:53	133119	24
C_3-Alkenylbiphenyl	1320	22:00	382463	68
Unknown	1328	22:08	208639	37
C_4-Alkylbiphenyl	1330	22:10	117375	21
$C_{14}H_{10}$	1335	22:15	493567	87
Fluorenone	1340	22:20	149247	26
Unknown	1342	22:22	89471	16
Biphenylylethanone	1357	22:37	407039	72
$C_{16}H_{22}$	1359	22:39	212479	38
Biphenylylethanone	1377	22:57	199935	35

[a]Composition from J. V. Zbozinek, J. R. Marsh, D. Guth, and A. Bohrnerud (SCS Engineers, Inc.). State-of-the-Art Review of Combustion and Pyrolysis By-Products of PCB Substitutes. Palo Alto, CA: Electric Power Research Institute, March 1986. EPRI EL-4503.

[b]Amount pyrolyzed = 980 µg.

[c]Yield is computed with respect to the mass of the sample pyrolyzed. Product amounts are determined by comparison of their areas with that of an external anthracene standard, assuming relative responses of one. Because of the assumptions implicit in the yield computations, the yield values are only within a factor of five. No internal standard methods or use of authentic standards were used to quantitate the products in this study.

[d]Major component of Wemcol, overloaded peak. Quantitation unreliable.

MONS 217704

Table A-53

WEMCOL FLUID (ISOPROPYLBIPHENYL)[a], 900°C COMBUSTION[b]

Tentative Identification	Scan	RT (min)	Area	Yield[c] (µg/g)
Toluene	333	5:33	117247	21
Chlorobenzene	486	8:06	168447	30
Styrene	601	10:01	250623	44
C_3-Alkylbenzene	705	11:45	204543	36
C_3-Alkenylbenzene	947	15:47	66943	12
C_3-Alkenylbenzene	1164	19:24	76415	14
Dichlorobenzene	1183	19:43	43839	7.8
Indene	1204	20:04	256767	46
C_4-Alkenylbenzene	1225	20:25	33407	5.9
Propedienylbenzene	1234	20:34	75135	13
Phenylethanone	1249	20:49	138751	25
Hexedecene	1273	21:13	132607	24
Alkane	1284	21:24	169215	30
Nonanal	1298	21:38	178175	32
Methylbenzofuran	1303	21:43	101375	18
Phenylpropanone	1337	22:17	135679	24
C_5-Alkenylbenzene	1344	22:24	72191	13
Methylindene	1353	22:33	97279	17
$C_{10}H_8$	1364	22:44	202239	36
Unknown	1369	22:49	181503	32
C_4-Alkenylbenzene	1371	22:51	204287	36
Dichlorophenol	1384	23:04	173055	31
Unknown	1389	23:09	54527	9.7
Alkene	1392	23:12	222463	39
Unknown	1402	23:22	133119	24
Alkylaldehyde	1409	23:29	219135	39
Dichlorophenol and unknown	1414	23:34	62975	11
Trichlorobenzene	1420	23:40	183807	33
$C_{10}H_{12}O$	1428	23:48	221951	39
Methylethylphenol	1435	23:55	185855	33
$C_{10}H_{12}O$	1443	24:03	118783	21
$C_{11}H_{12}O$	1456	24:16	185087	33
Cycloalkane	1466	24:26	210175	37
Alkane	1471	24:31	216063	38
C_9H_8O	1476	24:36	60415	11
$C_{11}H_{10}$	1480	24:40	242175	43
Siloxane	1483	24:43	93183	17
C_6-Alkadienylbenzene	1485	24:45	153343	27
$C_{11}H_{10}$	1492	24:52	281599	50
C_6-Alkadienylbenzene	1498	24:58	22719	4.0
Alkene	1523	25:23	414719	73
Biphenyl	1531	25:31	369151	65
Siloxane	1559	25:59	55231	9.8
C_3-Alkylbiphenyl[d]	1630	27:10	284159	50
C_3-Alkenylbiphenyl	1711	28:31	117631	21
C_4-Alkylbiphenyl	1714	28:34	100863	18

(continued)

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Table A-53 (concluded)

Tentative Identification	Scan	RT (min)	Area	Yield[c] (µg/g)
C_3-Alkenylbiphenyl	1726	28:46	119807	21
C_3-Alkenylbiphenyl	1729	28:49	144895	26
$C_{14}H_{10}$	1732	28:52	256255	45
Fluorenone	1735	28:55	175615	31
Biphenylylethenone	1737	28:57	452607	80
Unknown	1742	29:02	78463	14
Biphenylylethenone	1746	29:06	465919	82
Unknown	1890	31:30	32959	5.8

[a]Composition from J. V. Zbozinek, J. R. Marsh, D. Guth, and A. Bohrnerud (SCS Engineers, Inc.). State-of-the-Art Review of Combustion and Pyrolysis By-Products of PCB Substitutes. Palo Alto, CA: Electric Power Research Institute, March 1986. EPRI EL-4503.

[b]Amount pyrolyzed = 980 µg.

[c]Yield is computed with respect to the mass of the sample pyrolyzed. Product amounts are determined by comparison of their areas with that of an external anthracene standard, assuming relative responses of one. Because of the assumptions implicit in the yield computations, the yield values are only within a factor of five. No internal standard methods or use of authentic standards were used to quantitate the products in this study.

[d]Major component of Wemcol, overloaded peak. Quantitation unreliable.

MONS 217706

Table A-54

EDISOL III (C_3-ALKYLBIPHENYLS AND PHENYLXYLYLETHANE[a]), 500°C PYROLYSIS

Tentative Identification	Scan	RT (min)	Area
Unknown	118	1:58	3199
Unknown	142	2:22	2319
Dimethylpentene	167	2:47	4687
Benzene	174	2:54	32511
Siloxane	246	4:06	1587
C_7H_{10}	268	4:28	2283
Toluene	274	4:34	41023
C_7H_8	302	5:02	5991
Octene	311	5:11	8687
C_7H_8	321	5:21	2983
Octene	325	5:25	4063
Siloxane	342	5:42	39167
Chlorobenzene	380	6:20	7551
Ethylbenzene	401	6:41	5847
Xylene	412	6:52	23583
Styrene	444	7:24	179711
Xylene	447	7:27	142591
Methylstyrene	568	9:28	18687
Unknown	574	9:34	1819
Siloxene	580	9:40	16143
Trimethylbenzene	584	9:44	3643
Benzofuran	591	9:51	2083
Ethyloctynol	634	10:34	6743
Dichlorobenzene	639	10:39	2187
Acetophenone	684	11:24	13295
Unknown	699	11:39	3135
Unknown	709	11:49	1587
Unknown	719	11:59	4167
Unknown	741	12:21	2859
C_4-alkenylbenzene	746	12:26	39359
Siloxene	766	12:46	5471
Methylindene	777	12:57	1559
Alkene	811	13:31	3807
Naphthelene	820	13:40	3419
Unknown alcohol	832	13:52	3043
Trichlorobenzene	850	14:10	1565
Alkene	914	15:14	2379
Siloxane	943	15:43	1733
Alkene	1009	16:49	3571
Biphenyl	1016	16:56	95615
Alkene	1098	18:18	3863
Alkene	1104	18:24	3259
Methylbiphenyl	1111	18:31	67583
Methylbiphenyl	1120	18:40	53695
C_2-Alkylbiphenyl	1147	19:07	2267
Unknown	1158	19:18	700
Unknown	1183	19:43	853

(continued)

MONS 217707

Table A-54 (concluded)

Tentative Identification	Scan	RT (min)	Area
C_2-Alkylbiphenyl	1188	19:48	93183
$C_{15}H_{14}$	1200	20:00	109439
C_2-Alkylbiphenyl	1205	20:05	65791
$C_{15}H_{16}$	1243	20:43	296959
$C_{15}H_{16}$	1268	21:08	256767
$C_{16}H_{16}$	1277	21:17	115455
Unknown	1315	21:55	265727
$C_{15}H_{16}$	1322	22:02	115711
C_4-Alkylbiphenyl	1328	22:08	17663
$C_{16}H_{16}$	1333	22:13	275455
C_4-Alkylbiphenyl	1336	22:16	22335
C_4-Alkylbiphenyl	1342	22:22	34495
Unknown	1372	22:52	13535
Bis(ethylphenyl)ethane	1377	22:57	135423
Unknown	1381	23:01	10127
Unknown	1388	23:08	7447
Bis(ethylphenyl)ethane	1403	23:23	112255
$C_{18}H_{20}$	1422	23:42	5687
$C_{18}H_{20}$	1428	23:48	11871
$C_{18}H_{22}$	1437	23:57	71935
Unknown	1449	24:09	16837
$C_{18}H_{22}$	1464	24:24	13567

[a] Composition of Material from Table 4, Pyrolysis and Combustion of Utility Materials: Electric Power Research Institute, August 8, 1986. RP 2028-16.

MONS 217708

Table A-55

EOISOL III (C_3-ALKYLBIPHENYLS AND PHENYLXYLYLETHANE[a]), 900°C PYROLYSIS

Tentative Identification	Scan	RT (min)	Area
Unknown	150	2:30	1514
Cyclohexadiene	171	2:51	4096
Ethylcyclohexane	178	2:58	3964
Benzene	186	3:06	31168
Cycloheptatriene	260	4:20	2928
Unknown	286	4:46	1350
Toluene	292	4:52	45504
Unknown	330	5:30	3436
Siloxane	360	6:00	13680
Chlorobenzene	397	6:37	5672
C_2-Alkylbenzene	418	6:58	10752
Xylene	428	7:08	35840
Unknown	432	7:12	6088
Styrene	462	7:42	299008
Xylene	465	7:45	132608
C_3-Alkylbenzene	503	8:23	58240
Propylbenzene	542	9:02	2888
C_3-Alkylbenzene	552	9:12	4776
Benzaldehyde	554	9:14	24640
C_3-Alkylbenzene	576	9:36	15024
C_3-Alkenylbenzene	578	9:38	16128
Alkene	584	9:44	11696
Benzonitrile	586	9:46	8928
Siloxane	588	9:48	16704
C_3-Alkenylbenzene	594	9:54	15264
Benzofuran	599	9:59	8464
Dichlorobenzene	609	10:09	1520
Chlorotoluene	620	10:20	2680
Unknown	630	10:30	4104
C_4-Alkynylbenzene	637	10:37	1248
Alkene	639	10:39	14080
C_9H_{10}	647	10:47	2728
C_3-Alkynylbenzene	658	10:58	9440
Cresol	670	11:10	4608
C_3-Alkylbenzene	687	11:27	16256
C_4-Alkylbenzene	703	11:43	13488
C_4-Alkenylbenzene	722	12:02	12432
C_9H_8O	728	12:08	2692
Dimethylheptadiene	744	12:24	18624
C_4-Alkenylbenzene	751	12:31	184832
$C_{13}H_{12}$	761	12:41	1130
Siloxane	767	12:47	21024
C_5-Alkylbenzene	769	12:49	3608
$C_{10}H_{10}$	780	13:00	9664
Methyleneindene	790	13:10	10560
Dihydronaphthalene	798	13:18	3336

(continued)

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Table A-55 (concluded)

Tentative Identification	Scan	RT (min)	Area
Alkene	812	13:32	12880
Naphthalene	822	13:42	64896
Unknown	831	13:51	9536
C_3-Alkenylbenzene	836	13:56	4012
C_3-Alkenylbenzene	843	14:03	6792
Dimethylbenzaldehyde	853	14:13	29600
Unknown	860	14:20	4632
Alkene	914	15:14	8368
Alkene	921	15:21	3188
$C_{11}H_{10}$	936	15:36	5432
Siloxane	943	15:43	3424
$C_{11}H_{10}$	954	15:54	3700
Alkene	1009	16:49	13916
Biphenyl	1019	16:59	234200
Alkene	1030	17:10	2976
Methylbiphenyl	1033	17:13	3124
Unknown	1071	17:51	1666
Unknown	1083	18:03	2947
Alkene	1089	18:09	2980
Alkene	1097	18:17	6536
Alkene	1103	18:23	4656
Methylbiphenyl	1110	18:30	89344
Methylbiphenyl	1119	18:39	75136
C_2-Alkylbiphenyl	1146	19:06	3752
Alkene	1182	19:42	2252
C_2-Alkylbiphenyl	1187	19:47	87168
$C_{15}H_{16}$	1189	19:49	37632
$C_{15}H_{14}$	1198	19:58	74880
C_2-Alkylbiphenyl	1203	20:03	73216
C_2-Alkylbiphenyl	1205	20:05	73344
Methylfluorene	1219	20:19	55616
$C_{15}H_{16}$	1239	20:39	164096
$C_{14}H_{12}$	1242	20:42	34240
$C_{15}H_{16}$	1262	21:02	295936
$C_{15}H_{16}$	1273	21:13	75904
$C_{15}H_{14}$	1281	21:21	86144
$C_{16}H_{16}$	1307	21:47	246016
$C_{15}H_{14}$	1316	21:56	97270
$C_{16}H_{16}$	1327	22:07	209152
$C_{14}H_{10}$	1329	22:08	38528
$C_{16}H_{18}$	1338	22:18	44032
$C_{17}H_{20}$	1352	22:32	28896
$C_{16}H_{22}$	1374	22:54	77184
$C_{16}H_{22}$	1400	23:20	50176
$C_{16}H_{22}$	1436	23:56	16640
Siloxane	1548	25:48	1098

[a]Composition of Material from Table 4, Pyrolysis and Combustion of Utility Materials: Electric Power Research Institute, August 8, 1986. RP 2028-16.

MONS 217710

Table A-56

EDISOL III (C_3-ALKYLBIPHENYLS AND PHENYLXYLYLETHANE[a]), 500°C COMBUSTION

Tentative Identification	Scan	RT (min)	Area
Benzene	113	1:53	77951
Unknown	127	2:07	5079
Methylhexatriene	218	3:38	6199
Unknown	223	3:43	4247
Toluene	225	3:45	59071
Methylhexatriene	244	4:04	2979
Cycloheptatriene	257	4:17	7079
Octene	268	4:28	1861
Methylcyclohexadiene	274	4:34	9167
Tetrachloroethylene	286	4:46	7343
Methylhexatriene	302	5:02	2427
Siloxene	304	5:04	15327
Chlorobenzene	345	5:45	12175
Ethylbenzene	369	6:09	7175
Xylene	382	6:22	55423
Styrene	422	7:02	198655
$C_8H_{10}O$	424	7:04	134399
Unknown	445	7:25	6039
Cyclohexenecarboxaldehyde	506	8:26	2495
Benzaldehyde	527	8:47	45439
Methylstyrene	554	9:14	13727
Bicycloheptanone	559	9:19	7199
Siloxane	568	9:28	8191
Trimethylbenzene	570	9:30	12095
Benzofuran	577	9:37	7119
Dichlorobenzene	588	9:48	5959
Dichlorobenzene	628	10:28	5087
Propynylbenzene	642	10:42	9647
Acetophenone	674	11:14	27391
C_4-Alkylbenzene	691	11:31	8183
Xylene	698	11:38	30495
C_4-Alkenylbenzene	711	11:51	11391
Unknown	713	11:53	3779
Methylbenzofuran	723	12:03	1837
C_4-Alkenylbenzene	741	12:21	139263
Siloxane	763	12:43	3595
Trichlorobenzene	805	13:25	3511
Naphthalene	815	13:35	7967
Unknown alcohol	828	13:48	3619
Trichlorobenzene	846	14:06	25503
Dimethylbenzaldehyde	851	14:11	4127
Dodecene	911	15:11	1205
Unknown	933	15:33	1797
Siloxane	941	15:41	1975
Dimethylacetophenone	957	15:57	6655
Tetrachlorobenzene	965	16:05	5087
Alkene	1007	16:47	1675

(continued)

MONS 217711

Table A-56 (concluded)

Tentative Identification	Scan	RT (min)	Area
Biphenyl	1014	16:54	156415
Alkene	1097	18:17	1271
Alkene	1103	18:23	3331
Methylbiphenyl	1110	18:30	83455
Methylbiphenyl	1118	18:38	57151
Pentachlorobenzene	1147	19:07	7567
Ethylbiphenyl	1187	19:47	82175
$C_{15}H_{16}$	1189	19:49	33791
Dimethylfluorene	1198	19:58	84735
Ethylbiphenyl	1204	20:04	44607
Dimethyl(phenylmethyl)benzene	1246	20:46	240895
Dimethyl(phenylmethyl)benzene	1271	21:11	238078
$C_{16}H_{16}$	1278	21:18	101179
Unknown	1319	21:59	211455
$C_{14}H_{12}$	1321	22:01	219391
$C_{15}H_{14}$	1326	22:06	129535
Unknown	1329	22:09	29151
$C_{16}H_{16}$	1331	22:11	23231
$C_{16}H_{16}$	1337	22:17	239359
Unknown	1339	22:19	45439
Unknown	1345	22:25	53759
Unknown	1351	22:31	18303
Phenylacetophenone	1367	22:47	44543
Unknown	1372	22:52	23295
$C_{16}H_{22}$	1378	22:58	148479
Unknown	1389	23:09	11903
$C_{16}H_{22}$	1403	23:23	139007
$C_{16}H_{16}$	1415	23:35	2435
Unknown	1420	23:40	24991
Unknown	1422	23:42	6599
Dimethylbenzophenone	1435	23:55	30495
$C_{16}H_{22}$	1437	23:57	82047
Tetramethylphenanthrene	1440	24:00	1671
Unknown	1444	24:04	12831
Unknown	1446	24:06	35519
Unknown	1449	24:09	8287
Unknown	1456	24:16	31455
Unknown	1461	24:21	13119
$C_{16}H_{22}$	1464	24:24	17215
Unknown	1485	24:45	6415
Unknown	1508	25:08	4223

[a]Composition of Material from Table 4, Pyrolysis and Combustion of Utility Materials: Electric Power Research Institute, August 8, 1986. RP 2028-16.

MONS 217712

Table A-57

EDISOL III (C_3 -ALKYLBIPHENYLS AND PHENYLXYLYLETHANE[a]), 900°C COMBUSTION

Tentative Identification	Scan	RT (min)	Area
Benzene	178	2:58	117168
Toluene	290	4:50	41600
C_7H_8	321	5:21	5368
C_7H_{10}	338	5:38	3396
Tetrachloroethylene	351	5:51	2944
Siloxane	368	6:08	10064
Ethylbenzene	434	7:14	4312
Xylene	447	7:27	23744
C_7H_{14}	452	7:32	3344
Styrene	488	8:08	291840
Methylethylidenecyclopentadiene	491	8:11	125824
C_8H_{14}	511	8:31	16256
C_3-Alkylbenzene	537	8:57	21248
Cyclohexenecarboxaldehyde	576	9:36	9552
Benzaldehyde	599	9:59	32288
C_3-Alkylbenzene	625	10:25	10608
C_3-Alkenylbenzene	628	10:28	9632
Siloxane	645	10:45	8240
C_3-Alkenylbenzene	648	10:48	11632
Benzofuran	654	10:54	9184
Unknown	661	11:01	4036
Dichlorobenzene	667	11:07	2452
Chlorotoluene	680	11:20	2824
Ethyloctynediol	706	11:46	22112
Dichlorobenzene	714	11:54	2492
Indene	730	12:10	7592
C_9H_{12}	770	12:50	25760
Methylbenzaldehyde	794	13:14	7880
Chloroxylene	802	13:22	2440
C_4-Alkenylbenzene	820	13:40	5472
Unknown	822	13:42	4568
Unknown	850	14:10	6384
C_4-Alkenylbenzene	855	14:15	4944
C_4-Alkenylbenzene	862	14:22	154366
Siloxane	895	14:55	4704
$C_{10}H_{10}$	905	15:05	2946
$C_{10}H_8$	921	15:21	6328
Trichlorobenzene	957	15:57	2336
Alkene	966	16:06	2408
Naphthalene	973	16:13	28480
Unknown	998	16:38	3836
Trichlorobenzene	1027	17:07	8448
Dimethylbenzaldehyde	1032	17:12	29216
Unknown	1056	17:36	2276
Unknown	1213	20:13	1169
Siloxane	1227	20:27	2287
$C_{10}H_{12}O$	1233	20:33	6184
Biphenyl	1303	21:43	164096

(continued)

MONS 217713

Table A-57 (concluded)

Tentative Identification	Scan	RT (min)	Area
$C_{12}H_{10}$	1305	21:45	192768
Unknown	1313	21:53	2067
Unknown	1400	23:20	1213
Methylbiphenyl	1404	23:24	72832
Methylbiphenyl	1412	23:32	47616
$C_{18}H_{18}$	1415	23:35	17024
Pentachlorobenzene	1435	23:55	2664
C_2-Alkylbiphenyl	1471	24:31	94720
Dimethylfluorene	1479	24:39	90880
C_2-Alkylbiphenyl	1484	24:44	67712
Methylfluorene	1495	24:55	34240
$C_{18}H_{18}$	1509	25:09	337408
$C_{18}H_{18}$	1527	25:27	360960
$C_{16}H_{18}$	1535	25:35	90112
$C_{18}H_{18}$	1560	26:00	374272
$C_{18}H_{14}$	1566	26:06	50112
$C_{18}H_{18}$	1572	26:12	228864
C_4-Alkylbiphenyl	1578	26:18	21280
$C_{18}H_{22}$	1599	26:39	97024
$C_{18}H_{22}$	1614	26:54	61184
$C_{18}H_{22}$	1636	27:16	29472

[a]Composition of Material from Table 4, Pyrolysis and Combustion of Utility Materials: Electric Power Research Institute, August 8, 1986. RP 2028-16.

MONS 217714

Table A-58

FORMEX WIRE ENAMEL (TOR-8), 900°C PYROLYSIS

Tentative Identification	Scan	RT (min)	Area
Pentenyne	52	0:52	2432
Methylpyrazole	60	1:00	1178
Unknown	68	1:08	157
Unknown	70	1:10	207
Benzene	74	1:14	3232
Unknown	90	1:30	63
Unknown	94	1:34	123
Unknown	129	2:09	127
Toluene	133	2:13	2692
Unknown	150	2:30	370
Siloxane	180	3:00	899
Unknown	203	3:23	325
Unknown	208	3:28	256
Ethylbenzene	215	3:35	813
Unknown	223	3:43	262
C_8H_8	243	4:03	1774
Unknown	250	4:10	307
Phenylbutenone	277	4:37	549
Propylbenzene	307	5:07	2348
C_3-alkylbenzene	317	5:17	11152
C_3-alkylbenzene	324	5:24	4728
Phenylcarbamate	346	5:46	7032
C_3-alkylbenzene	352	5:52	16160
Phenol	356	5:56	35136
Unknown	360	6:00	110
Unknown	364	6:04	229
Unknown	366	6:06	142
Unknown	368	6:08	178
C_3-alkylbenzene	378	6:18	4336
Dihydroindene	391	6:31	2296
Unknown	399	6:39	247
C_4-alkylbenzene	404	6:44	7352
C_4-alkylbenzene	413	6:53	12800
C_4-alkylbenzene	420	7:00	3448
C_4-alkylbenzene	433	7:13	17376
C_4-alkylbenzene	440	7:20	17280
Unknown	445	7:25	738
Unknown	449	7:29	238
C_4-alkylbenzene	458	7:38	6360
C_4-alkylbenzene	468	7:48	15360
C_4-alkylbenzene	473	7:53	17696
Methyldihydroindene	488	8:08	6432
C_5-alkylbenzene	493	8:13	3136
C_5-alkylbenzene	499	8:19	12448
Unknown	506	8:26	1224
C_2-alkylphenol	515	8:35	7632
C_5-alkylbenzene	521	8:41	3260
Methyleneindene	531	8:51	23552

(continued)

MONS 217715

Table A-58 (concluded)

Tentative Identification	Scan	RT (min)	Area
C_2-Alkylphenol	536	8:56	2068
C_6-Alkylbenzene	540	9:00	4696
Unknown	545	9:05	385
C_5-Alkylbenzene	550	9:10	2472
Unknown	567	9:27	445
Unknown	572	9:32	732
Unknown	574	9:34	405
Unknown	578	9:38	539
Phenyl butanoate	584	9:44	3228
Unknown	592	9:52	718
C_3-Alkylphenol	599	9:59	232
C_3-Alkylphenol	603	10:03	224
C_5-Alkylbenzene	611	10:11	729
Unknown	616	10:16	148
Ethylideneindene	623	10:23	2832
Unknown	638	10:38	658
Unknown	697	11:37	230
Unknown	703	11:43	133
Unknown	758	12:38	169
Alkene	761	12:41	1720
Trimethylcyclopentane	773	12:53	416
Unknown	779	12:59	256
Diethyl phthalate	852	14:12	2588
Unknown	855	14:15	143
Unknown	900	15:00	291
Unknown	916	15:16	204
Unknown	921	15:21	286
Unknown	924	15:24	407
Unknown	929	15:29	720
Nonylphenol	935	15:35	1232
Nonylphenol	939	15:39	790
Unknown	942	15:42	344
Unknown	949	15:49	224
Unknown	954	15:54	293
Unknown	957	15:57	58
Unknown	960	16:00	460
Unknown	966	16:06	243
Phthalate ester	1091	18:11	6152
Unknown	1100	18:20	619
Hexadecanoic acid	1217	20:17	38208
Unknown	1224	20:24	793
Unknown	1267	21:07	409
Octadecanoic acid, 2-methylpropyl ester	1319	21:59	13344

MONS 217716

Table A-59

KRAFT PHENOLIC LAMINATE (HERKOLITE TOR-6), 900°C PYROLYSIS

Tentative Identification	Scan	RT (min)	Area
Methylfuran	85	1:25	18656
Benzene	99	1:39	26240
Unknown	115	1:55	5088
Unknown	122	2:02	7624
Toluene	145	2:25	57536
Siloxane	182	3:02	72576
Vinylbutenal	189	3:09	28576
C_3-Alkylpyrrolidine	191	3:11	5664
Ethylbenzene	214	3:34	50048
Unknown	273	4:33	16448
Unknown	283	4:43	23968
C_3-Alkylbenzene	294	4:54	10032
Phenol	318	5:18	83968
Hydroxybenzaldehyde	359	5:59	7024
Cresol	381	6:21	71552
Cresol	400	6:40	102016
Methoxyphenol	406	6:46	5824
Cinnamaldehyde	409	6:49	9024
C_2-Alkylphenol	418	6:58	53184
C_2-Alkylphenol	445	7:25	10432
C_2-Alkylphenol	460	7:40	89344
C_2-Alkylphenol	471	7:51	9200
C_3-Alkylphenol	484	8:04	6904
C_3-Alkylcyclohexenol	493	8:13	11744
C_3-Alkylphenol	503	8:23	47104
Unknown	515	8:35	9696
C_3-Alkylphenol	521	8:41	6560
Naphthalenamine	563	9:23	31872
Methylphenylbutenone	588	9:48	7656
Siloxane	601	10:01	14736
(Methylphenyl)pyrrole	649	10:49	25504
(Aminoethyl)quinolinol	779	12:59	16384
Dihydrotrimethylnaphthalenone	828	13:48	19744
Xanthene	841	14:01	5816
Acridine	942	15:42	14352
Methylacridine	983	16:23	11360
Methylacridine	1018	16:58	27168
Methylphenylindole	1052	17:32	8304
Methylphenolindole	1088	18:08	7600

MONS 217717

Table A-60

KRAFT PHENOLIC LAMINATE (SPAULDITE, TOR-7),900°C PYROLYSIS

Tentative Identification	Scan	RT (min)	Area
Unknown	81	1:21	10496
Unknown	84	1:24	19872
Benzene	100	1:40	51520
C_8H_{10}	105	1:45	15712
Unknown	118	1:58	9456
Unknown	124	2:04	11920
Toluene	146	2:26	94464
Methylbutenal	150	2:30	6728
Siloxane	181	3:01	69888
Unknown	188	3:08	40768
Ethylbenzene	214	3:34	89344
Unknown	272	4:32	15616
Trimethylbenzene	294	4:54	32544
Methylfuranone	307	5:07	53056
Phenol	331	5:31	52032
2-Hydroxybenzaldehyde C_9H_8	361	6:01	14352
Cresol	388	6:28	76928
Cresol	410	6:50	94976
Xylenol + $C_{10}H_{12}$	419	6:59	48320
Xylenol	428	7:08	72320
Unknown alcohol	443	7:23	7728
Ethylphenol	450	7:30	24576
Xylenol	468	7:48	104832
Ethylphenol	478	7:58	23424
C_3-Alkylphenol	488	8:08	14976
Unknown mixture	499	8:19	18912
Trimethylphenol	508	8:28	52032
Dimethylbenzofuran	511	8:31	14432
Trimethylphenol	524	8:44	17376
C_3-Alkylphenol	533	8:53	18112
Unknown mixture	559	9:19	12128
$C_{10}H_9N$	565	9:25	40640
$C_{11}H_{10}$	576	9:36	11712
Methylphenylbutanone	590	9:50	10448
C_4-Alkylphenol	593	9:53	14032
Unknown	596	9:56	10832
Siloxane	601	10:01	16480
Dimethoxyphenol	625	10:25	27360
$C_{11}H_{11}N$	650	10:50	32320
Trimethoxybenzene	696	11:36	23392
Unknown	720	12:00	8560
Siloxane	732	12:12	28352
$C_{14}H_{14}$	753	12:33	16416
Unknown	782	13:02	27840
Dodecanoic acid	789	13:09	13600
Unknown	830	13:50	28672

(continued)

MONS 217718

Table A-60 (concluded)

Tentative Identification	Scan	RT (min)	Area
Xanthene	842	14:02	16544
Unknown	867	14:27	9312
Unknown	874	14:34	7688
Unknown	898	14:58	14544
Acridine	919	15:19	14448
Methylacridine	944	15:44	12864
Phthalate ester	1019	16:59	21440
Methylphenylindole	1035	17:15	20096
	1089	18:09	7808

MONS 217719

Appendix B

PRODUCT SUMMARY TABLES FOR PYROLYSIS AND
COMBUSTION OF UTILITY MATERIALS

Appendix B contains summary tables of the thermal degradation products for the utility materials screened during the project. For each thermal test, the number of occurrances of several compound classes are tabulated and example products are listed to provide a ready guide to the types of thermal degradation products produced by each material.

MDNS 217720

Table B-1

SUMMARY OF PRODUCTS FOUND IN PVC CONDUIT, 500°C PYROLYSIS[a]

Class	Number	Examples
Chlorinated aromatics	1 + (5)	(Chlorobenzene, trichlorobenzene, chlorotoluene)
Chlorinated aliphetics	1 + (1)	(Tetrachloroethene), dichloropropene
Oxygen heterocycles	1	Dibenzofuran
Phenols and other hydroxy aromatics	1	Phenol
Aromatic hydrocarbons	11 + (1)	(Benzene), naphthalene, anthracene
Alkyl aromatics	7	Toluene, styrene
Aldehydes and ketones	(1)	(Benzaldehyde)
Phthalate esters	1	
Saturated and cyclic hydrocarbons	4	
Siloxanes	(8)	Not applicable
Unknowns	8	Not applicable

[a]Numbers and example compounds in parentheses are suspected to be background.

MONS 217721

Table B-2

SUMMARY OF PRODUCTS FOUND IN PVC CONDUIT, 900°C PYROLYSIS[a]

Class	Number	Examples
Chlorinated aromatics	1 + (3)	(Chlorobenzene, trichlorobenzene, chlorotoluene)
Chlorinated aliphatics	1 + (1)	(Tetrachloroethene), 1-Chloroheptane
Oxygen heterocycles	1	Dibenzofuren
Aromatic hydrocarbons	9 + (1)	(Benzene), indene, naphthalene, anthracene
Alkyl aromatics	7	Toluene, styrene, diphenylethane
Aldehydes and ketones	(1)	(Benzaldehyde)
Siloxanes	(7)	Not applicable
Unknowns	15	Not applicable

[a]Numbers and example compounds in parentheses are suspected to be background.

MONS 217722

Table B-3

SUMMARY OF PRODUCTS FOUND IN PVC CONDUIT, 500°C COMBUSTION[a]

Class	Number	Examples
Chlorinated aromatics	1 + (6)	(Chlorobenzene, pentachlorobenzene), chlorotoluene
Chlorinated aliphatics	(1)	Tetrachloroethene
Oxygen heterocycles	2	Benzofuren, C_8H_8O
Phenols and other hydroxy aromatics	1	Trichlorophenol
Aromatic hydrocarbons	7 + (1)	(Benzene), naphthalene, anthracene
Alkyl aromatics	5	Styrene
Aldehydes and ketones	3 + (1)	(Benzaldehyde), phenylpropenal
Saturated and cyclic hydrocarbons	2	
Siloxanes	(6)	Not applicable
Unknowns	13	Not applicable

[a]Numbers and example compounds in parentheses are suspected to be background.

MONS 217723

Table B-4

SUMMARY OF PRODUCTS FOUND IN PVC CONDUIT, 900°C COMBUSTION[a]

Class	Number	Examples
Chlorinated aromatics	(6)	(Chlorobenzene, trichlorobenzene, hexechlorobenzene)
Chlorinated aliphatics	(1)	(Tetrachloroethene)
Phenols and other hydroxy aromatics	1	Trichlorophenol
Aromatic hydrocarbons	7 + (1)	(Benzene), naphthalene, biphenyl, anthracene
Aldehydes and ketones	3 + (1)	(Benzaldehyde), phenylpropenel, benzophenone
Acids	1	Phthalic acid
Unsatureted hydrocarbons	1	Alkadiene
Saturated and cyclic hydrocarbons	3	
Siloxanes	(7)	Not applicable
Unknowns	11	Not applicable

[a]Numbers and example compounds in perentheses ere suspected to be background.

MONS 217724

Table B-5

SUMMARY OF PRODUCTS FOUND IN FORMEL NF (MIXTURE OF PERCHLOROETHYLENE AND FREONS)[a], 500°C PYROLYSIS[b]

Class	Number	Examples
Chlorinated aromatics	(2)	(Dichlorobenzene)
Chlorinated aliphatics	11	Trichlorotrifluoroethane
Oxygen heterocycles	1	Methyltetrahydrofuran
Aromatic hydrocarbons	(1)	(Biphenyl)
Alkyl aromatics	(1)	(C_5-Alkyl biphenyl)
Unsaturated hydrocarbons	2	
Saturated and cyclic hydrocarbons	3	
Siloxanes	(5)	Not applicable
Unknowns	14	Not applicable

[a]Composition from J. V. Zbozinek, J. R. Marsh, D. Guth, and A. Bohrnerud (SCS Engineers, Inc.). State-of-the-Art Review of Combustion and Pyrolysis By-Products of PCB Substitutes. Palo Alto, CA: Electric Power Research Institute, March 1986. EPRI EL-4503.

[b]Numbers and example compounds in parentheses are suspected to be background.

MONS 217725

Table B-6

SUMMARY OF PRODUCTS FOUND IN FORMEL NF (MIXTURE OF PERCHLOROETHYLENE AND FREONS)[a], 900°C PYROLYSIS[b]

Class	Number	Examples
Chlorinated aromatics	(3)	(Chlorobenzene, trichlorobenzene)
Chlorinated aliphatics	13	Tetrachlorodifluoroethane, trichloromethylpropene
Fluorinated aliphatics	1	Fluorinated alkane
Alkyl aromatics	(2)	(C_3-Alkyl biphenyl)
Aldehydes and ketones	(1)	(Benzaldehyde)
Saturated and cyclic hydrocarbons	6	Dimethylcyclopentane
Siloxanes	(5)	Not applicable
Unknowns	6	Not applicable

[a]Composition from J. V. Zbozinek, J. R. Marsh, D. Guth, and A. Bohrnerud (SCS Engineers, Inc.). State-of-the-Art Review of Combustion and Pyrolysis By-Products of PCB Substitutes. Palo Alto, CA: Electric Power Research Institute, March 1986. EPRI EL-4503.

[b]Numbers and example compounds in parentheses are suspected to be background.

MONS 217726

Table B-7

SUMMARY OF PRODUCTS FOUND IN FORMEL NF (MIXTURE OF PERCHLOROETHYLENE AND FREONS)[a], 500°C COMBUSTION[b]

Class	Number	Examples
Chlorinated aromatics	(9)	(Dichlorobenzene, tetrachlorobenzene)
Chlorinated aliphatics	11	Trichlorotrifluoroethane, hexachloroethane
Fluorinated aliphatics	1	
Aldehydes and ketones	(1)	(Benzaldehyde)
Alcohols	1	Octanol
Unsaturated hydrocarbons	1	
Saturated and cyclic hydrocarbons	3	
Siloxanes	(6)	Not applicable
Unknowns	7	Not applicable

[a]Composition from J. V. Zbozinek, J. R. Marsh, D. Guth, and A. Bohrnerud (SCS Engineers, Inc.). State-of-the-Art Review of Combustion and Pyrolysis By-Products of PCB Substitutes. Palo Alto, CA: Electric Power Research Institute, March 1986. EPRI EL-4503.

[b]Numbers and example compounds in parentheses are suspected to be background.

MONS 217727

Table B-8

SUMMARY OF PRODUCTS FOUNO IN FORMEL NF (MIXTURE OF PERCHLOROETHYLENE AND FREONS)[a], 900°C COMBUSTION[b]

Class	Number	Examples
Chlorinated aromatics	(11)	(Chlorobenzenes - mono to hexa)
Chlorinated aliphatics	7	Tetrachlorodifluoroethane, hexachloroethane
Fluorinated aliphatics	1	Fluorinated alkane
Nitriles	1	Benzonitrile
Phenols and other hydroxy aromatics	1	Phenol
Alkyl aromatics	(1)	(C_3-Alkyl benzene)
Aldehydes and ketones	1 + (1)	(Benzaldehyde), fluorenone
Unsaturated hydrocarbons	4	
Saturated and cyclic hydrocarbons	3	
Siloxanes	(6)	Not applicable
Unknowns	7	Not applicable

[a]Composition from J. V. Zbozinek, J. R. Marsh, D. Guth, and A. Bohrnerud (SCS Engineers, Inc.). State-of-the-Art Review of Combustion and Pyrolysis By-Products of PCB Substitutes. Palo Alto, CA: Electric Power Research Institute, March 1986. EPRI EL-4503.

[b]Numbers and example compounds in parentheses are suspected to be background.

MONS 217728

Table B-9

SUMMARY OF PRODUCTS FOUND IN WECOSOL[b] (PERCHLOROETHYLENE)[a], 500°C PYROLYSIS[b]

Class	Number	Examples
Chlorinated aromatics	(3)	(Chlorobenzenes)
Chlorinated aliphatics	1	Tetrachloroethylene
Oxygen heterocycles	1	Tetrahydromethylfuran
Aromatic hydrocarbons	1 + (1)	(Biphenyl), ethylidene indene
Alkyl aromatics	1 + (1)	(C_3-Alkyl biphenyl), dimethyl naphthalene
Unsaturated hydrocarbons	2	
Saturated and cyclic hydrocarbons	9	
Siloxanes	(6)	Not applicable
Unknowns	7	Not applicable

[a]Composition from J. V. Zbozinek, J. R. Marsh, D. Guth, and A. Bohrnerud (SCS Engineers, Inc.). State-of-the-Art Review of Combustion and Pyrolysis By-Products of PCB Substitutes. Palo Alto, CA: Electric Power Research Institute, March 1986. EPRI EL-4503.

[b]Numbers and example compounds in parentheses are suspected to be background.

MONS 217729

Table B-10

SUMMARY OF PRODUCTS FOUND IN WECOSOL (PERCHLOROETHYLENE)[a], 900°C PYROLYSIS[b]

Class	Number	Examples
Chlorinated aromatics	(6)	(Chlorobenzenes)
Chlorinatad aliphatics	5	Trichloroethylene, tetrachloroethylene
Alkyl aromatics	(1)	(C_3-Alkyl biphenyl)
Unsaturated hydrocarbons	2	
Saturated and cyclic hydrocarbons	2	
Siloxanes	(6)	Not applicable
Unknowns	4	Not applicable

[a]Composition from J. V. Zbozinek, J. R. Marsh, D. Guth, and A. Bohrnerud (SCS Engineers, Inc.). State-of-the-Art Review of Combustion and Pyrolysis By-Products of PCB Substitutes. Palo Alto, CA: Electric Power Research Institute, March 1986. EPRI EL-4503.

[b]Numbers and example compounds in parentheses are suspected to be background.

MONS 217730

Table B-11

SUMMARY OF PRODUCTS FOUND IN WECOSOL (PERCHLOROETHYLENE)[a], 500°C COMBUSTION[b]

Class	Number	Examples
Chlorinated aromatics	(7)	(Chlorobenzenes)
Chlorinated aliphatics	4	Tetrachloroethylene, hexachloropropene
Aldehydes and ketones	(1)	(Benzaldehyde)
Saturated and cyclic hydrocarbons	2	Cyclopropylcyclohexane
Siloxanes	(5)	Not applicable
Unknowns	3	Not applicable

[a]Composition from J. V. Zbozinek, J. R. Marsh, D. Guth, and A. Bohrnerud (SCS Engineers, Inc.). State-of-the-Art Review of Combustion and Pyrolysis By-Products of PCB Substitutes. Palo Alto, CA: Electric Power Research Institute, March 1986. EPRI EL-4503.

[b]Numbers and example compounds in parentheses are suspected to be background.

MONS 217731

Table B-12

SUMMARY OF PRODUCTS FOUND IN WECOSOL (PERCHLOROETHYLENE)[a], 900°C COMBUSTION[b]

Class	Number	Examples
Chlorinated aromatics	(5)	(Chlorobenzenes)
Chlorinated aliphatics	3	Tetrachloroethylene, trichloroethylene
Oxygen heterocyclas	1	Tetrahydromethylfuran
Aldehydes and ketones	(1)	(Benzaldehyde)
Unsaturated hydrocarbons	1	
Saturated and cyclic hydrocarbons	4	Diethylcyclobutane
Siloxanes	(5)	Not applicable
Unknowns	4	Not applicable

[a]Composition from J. V. Zbozinek, J. R. Marsh, D. Guth, and A. Bohrnerud (SCS Engineers, Inc.). State-of-the-Art Review of Combustion and Pyrolysis By-Products of PCB Substitutes. Palo Alto, CA: Electric Power Research Institute, March 1986. EPRI EL-4503.

[b]Numbers and example compounds in parentheses are suspected to be background.

Table B-13

SUMMARY OF PRODUCTS FOUND IN ELECTROCHEM FR-15 (CHLOROBENZENE MIX)[a], 500°C PYROLYSIS[b]

Class	Number	Examples
Chlorinated aromatics	18	Hexachlorobiphenyl, bromochlorobenzene
Chlorinated aliphatics	2	Tetrachloroethylene, methylene chloride
Oxygen heterocycles	1	Tetrahydromethylfuran
Aromatic hydrocarbons	2	Terphenyl, phenylbicyclohexyl
Alkyl aromatics	1 + (1)	(Toluene), xylene
Unsaturated hydrocabons	2	
Siloxanes	(4)	Not applicable
Unknowns	3	Not applicable

[a]Composition from J. V. Zbozinek, J. R. Marsh, D. Guth, and A. Bohrnerud (SCS Engineers, Inc.). State-of-the-Art Review of Combustion and Pyrolysis By-Products of PCB Substitutes. Palo Alto, CA: Electric Power Research Institute, March 1986. EPRI EL-4503.

[b]Numbers and example compounds in parentheses are suspected to be background.

MONS 217733

Table B-14

SUMMARY OF PRODUCTS FOUND IN ELECTROCHEM FR-15 (CHLOROBENZENE MIX)[a], 900°C PYROLYSIS

Class	Number	Examples
Chlorinated aromatics	19	Hexachlorobiphenyl, chlorobenzenes
Chlorinated aliphatics	2	Tetrachloroethylene, methylene chloride
Oxygen heterocycles	1	Tetrahydromethylfuran
Aromatic hydrocarbons	5	Terphenyls, phenyl bicyclohexyl
Alkyl aromatics	(2)	(Toluene, C_3-alkyl biphenyl)
Unsaturated hydrocarbons	4	$C_{14}H_{20}$, C_7H_{10}
Saturated and cyclic hydrocarbons	1	
Siloxanes	(2)	Not applicable
Unknowns	7	Not applicable

[a]Composition from J. V. Zbozinek, J. R. Marsh, D. Guth, and A. Bohrnerud (SCS Engineers, Inc.). State-of-the-Art Review of Combustion and Pyrolysis By-Products of PCB Substitutes. Palo Alto, CA: Electric Power Research Institute. March 1986. EPRI EL-4503.

[b]Numbers and example compounds in parentheses are suspected to be background.

MONS 217734

Table B-15

SUMMARY OF PRODUCTS FOUND IN ELECTROCHEM FR-15 (CHLOROBENZENE MIX)[a], 500°C COMBUSTION

Class	Number	Examples
Chlorinated aromatics	18	Bromochlorobenzene, chlorotoluenes
Chlorinated aliphatics	2	Tetrachloroethylene, methylene chloride
Oxygen heterocycles	1	Tetrahydromethylfuran
Aromatic hydrocarbons	2	Terphenyls
Alkyl aromatics	(1)	(Toluene)
Aldehydes and ketones	(1)	(Benzaldehyde)
Unsaturated hydrocarbons	1	
Siloxanes	(4)	Not applicable
Unknowns	3	Not applicable

[a]Composition from J. V. Zbozinek, J. R. Marsh, D. Guth, and A. Bohrnerud (SCS Engineers, Inc.). State-of-the-Art Review of Combustion and Pyrolysis By-Products of PCB Substitutes. Palo Alto, CA: Electric Power Research Institute, March 1986. EPRI EL-4503.

[b]Numbers and example compounds in parentheses are suspected to be background.

MONS 217735

Table B-16

SUMMARY OF PRODUCTS FOUND IN ELECTROCHEM FR-15 (CHLOROBENZENE MIX)[a], 900°C COMBUSTION

Class	Number	Examples
Chlorinated aromatics	14	Chlorobenzenes, tetrachlorotoluene
Chlorinated aliphatics	3	Tetrachloroethylene, methylene chloride
Aromatic hydrocarbons	1	Terphenyl
Alkyl aromatics	(1)	(Toluene)
Unsaturated hydrocabons	1	
Siloxanes	(4)	Not applicable
Unknowns	6	Not applicable

[a]Composition from J. V. Zbozinek, J. R. Marsh, D. Guth, and A. Bohrnerud (SCS Engineers, Inc.). State-of-the-Art Review of Combustion and Pyrolysis By-Products of PCB Substitutes. Palo Alto, CA: Electric Power Research Institute, March 1986. EPRI EL-4503.

[b]Numbers and example compounds in parentheses are suspected to be background.

MONS 217736

Table B-17

SUMMARY OF PRODUCTS FOUND IN DICY KRAFT PAPER (TOR-1), 500°C PYROLYSIS[a]

Class	Number	Examples
Chlorinated aromatics	(1)	(Chlorobenzene)
Chlorinated aliphatics	1	(Dichloroethene)
Oxygen heterocycles	5	Methylfuran, dimethylfuran
Phenols and other hydroxy aromatics	(1)	(Tetrachlorophenol)
Aromatic hydrocarbons	7 + (1)	(Benzene), biphenyl, naphthalene
Alkyl aromatics	4	C_2-alkylbenzene, C_3-alkenylbenzene
Aldehydes and ketones	6 + (1)	Butanedione, nonanal, tetradecanal
Alcohols	1	Furanmethanol
Phthalate esters	6	
Acids	8	Acetic acid, tetradecanoic acid
Unsaturated hydrocarbons	8	
Saturated and cyclic hydrocarbons	7	
Siloxanes	(6)	Not applicable
Unknowns	44	Not applicable

[a]Numbers of specific compounds in parentheses are suspected to be background.

MONS 217737

Table B-18

SUMMARY OF PRODUCTS FOUND IN DICY KRAFT PAPER (TOR-1), 900°C PYROLYSIS[a]

Class	Number	Examples
Chlorinated aromatics	(1)	(Chlorobenzene)
Aromatic hydrocarbons	11 + (1)	(Benzene), indene, biphenyl, anthracene
Alkyl aromatics	22	Toluene, styrene, methylnaphthalene
Aldehydes and ketones	1	
Alcohols	1	Methylhexadecanol
Phthalate esters	3	
Acids	5	Dodecanoic acid, tetradecanoic acid
Unsaturated hydrocarbons	10	
Saturated and cyclic hydrocarbons	5	
Siloxanes	7	Not applicable
Unknowns	11	Not applicable

[a]Numbers and example compounds in parentheses are suspected to be background.

MONS 217738

Table B-19

SUMMARY OF PRODUCTS FOUND IN DICY KRAFT PAPER (TOR-1), 500°C COMBUSTION[a]

Class	Number	Examples
Chlorinated aromatics	(2)	(Chlorobenzene, trichlorobenzene)
Chlorinated aliphatics	(3)	(Dichloroethene, methylene chloride)
Nitriles	2	Alkane nitrile, benzonitrile
Phenols and other hydroxy aromatics	1	Phenol
Aromatic hydrocarbons	1 + (1)	(Benzene), biphenyl
Alkyl aromatics	(1)	($C_{15}H_{16}$)
Aldehydes and ketones	18	Octanal, nonanal, dodecanal
Phthalate esters	2	
Other esters	3	Propenylformate, propanoic acid, alkyl ester
Acids	4	Acetic acid, nonanoic acid
Unsaturated hydrocarbons	6	Alkenes
Saturated and cyclic hydrocarbons	9	Alkanes
Siloxanes	7	Not applicable
Unknowns	26	Not applicable

[a]Numbers and example compounds in parentheses are suspected to be background.

MONS 217739

Table B-20

SUMMARY OF PRODUCTS FOUND IN DICY KRAFT PAPER (TOR-1), 900°C COMBUSTION[a]

Class	Number	Examples
Chlorinated aromatics	(4)	(Chlorobenzene, dichlorobenzene)
Nitriles	1	Benzonitrile
Oxygen heterocycles	4	Benzofuran, dibenzofuran
Phenols and other hydroxy aromatics	3	Phenol, methylphenol
Aromatic hydrocarbons	8 + (2)	(Benzene), indene, naphthalene
Alkyl aromatics	16 + (2)	(Toluene), styrene, C_4-alkylbenzene
Aldehydes and ketones	8 + (1)	(Benzaldehyde), acetophenone, undecanal
Phthalate esters	3	
Acids	5	Tetradecanoic acid, hexadecanoic acid
Unsaturated hydrocarbons	7	
Saturated and cyclic hydrocarbons	1	
Siloxanes	(9)	Not applicable
Unknowns	15	Not applicable

[a]Numbers and example compounds in parentheses are suspected to be background.

MONS 217740

Table B-21

SUMMARY OF PRODUCTS FOUND IN DICY CREPE PAPER (TOR-4), 900°C PYROLYSIS[a]

Class	Number	Examples
Nitrogen heterocycles	2	Methylpyrrole, pyridine
Oxygen heterocycles	4	Methylfuran, furanathanone
Phenols and other hydroxy aromatics	10	Phenol, cresol, benzenediol
Aromatic hydrocarbons	1+(1)	Indene, (benzene)
Alkyl aromatics	6+(1)	C_4-Alkenylbenzene, (toluene)
Aldehydes and ketones	7	Methylbutenal, methylcyclopentenone dihydroindenone
Unsaturated hydrocarbons	1	Cyclohexadiene
Saturated and cyclic hydrocarbons	2	
Siloxanes	(3)	Not applicable
Unknowns	26	Not applicable

[a]Numbers and example compounds in parentheses are suspected to be background.

MONS 217741

Table B-22

SUMMARY OF PRODUCTS FOUND IN NITRILE RUBBER (TOR-9), 500°C PYROLYSIS[a]

Class	Number	Examples
Nitriles	1	Alkatriene nitrile
Nitrogen heterocycles	3	Dihydroindole, C_3-alkyldihydroquinoline
Sulfur heterocycles	2	Benzothiazole, methylthiobenzothiazole acid
Phenols and other hydroxy aromatics	2	Phenol, C_3-alkynyloxybenzene
Aromatic hydrocarbons	2 + (1)	(Benzene), indene
Alkyl aromatics	7	Styrene, C_3-alkenylbenzene
Aldehydes and ketones	1 + (1)	(Benzaldehyde), acetophenone
Phthalate esters	3	
Acids	10	Nonenoic acid, dodecenoic acid
Unsaturated hydrocarbons	9	Alkenes
Saturated and cyclic hydrocarbons	6	
Siloxanes	(2)	Not applicable
Unknowns	18	Not applicable

[a]Numbers and example compounds in parentheses are suspected to be background.

MONS 217742

Table B-23

SUMMARY OF PRODUCTS FOUND IN NITRILE RUBBER (TOR-9), 900°C PYROLYSIS[a]

Class	Number	Examples
Nitriles	3	Benzonitrile, methylbenzonitrile
Nitrogen heterocycles	1	C_8H_7N
Sulfur heterocycles	1	Benzothiazole
Phenols and other hydroxy aromatics	2	Phenol, C_3-alkynyloxybenzene
Aromatic hydrocarbons	10 + (1)	(Benzene), indene, fluorene, anthracene
Alkyl aromatics	27	C_2-alkylbenzene, C_3-alkenylbenzene, methylbiphenyl
Aldehydes and ketones	3 + (1)	(Benzaldehyde), acetophenone, nonanal
Alcohols	1	Alkanol
Phthalate esters	6	
Acids	5	Nonanoic acid, dodecanoic acid
Unsaturated hydrocarbons	9	Alkenes, dienes
Setureted and cyclic hydrocarbons	6	Alkanes
Siloxanes	(5)	Not applicable
Unknowns	17	Not applicable

[a]Numbers and example compounds in parentheses are suspected to be background.

MONS 217743

Table B-24

SUMMARY OF PRODUCTS FOUND IN NITRILE RUBBER (TOR-9), 500°C COMBUSTION[a]

Class	Number	Examples
Chlorinated aromatics	(1)	(Chlorobenzene)
Nitriles	3	Benzonitrile, alkylnitriles
Nitrogen heterocycles	1	N-propylbenzamide
Sulfur heterocycles	1	Benzothiazole
Oxygen heterocycles	1	Methylfuran
Phenols and other hydroxy aromatics	2	Phenol, ethoxybenzene
Aromatic hydrocarbons	2 + (1)	(Benzene), indene
Alkyl aromatics	7	Toluene, styrene, C_3-alkenylbenzene
Aldehydes and ketones	9 + (1)	(Benzaldehyde), heptanal, decanal
Phthalate esters	5	
Other esters	1	Phenyl carbamate
Acids	9	Nonanoic acid, tetradecanoic acid
Unsaturated hydrocarbons	5	
Saturated and cyclic hydrocarbons	1	
Unknowns	12	Not applicable

[a]Numbers and example compounds in parentheses are suspected to be background.

MONS 217744

Table B-25

SUMMARY OF PRODUCTS FOUND IN NITRILE RUBBER (TOR-9), 900°C COMBUSTION[a]

Class	Number	Examples
Chlorinated aromatics	(2)	(Chlorobenzene)
Nitriles	5	Propenenitrile, benzonitrile, methylbenzonitrile
Nitrogen heterocycles	3	Quinoline, dimethylquinoline
Sulfur heterocycles	1	Benzothiophene
Oxygen heterocycles	2	Benzofuran, dibenzofuran
Phenols and other hydroxy erometics	4	Phenol, methylphenol, methoxybenzene
Aromatic hydrocarbons	10 + (1)	(Benzene), nephthalene, enthrecene
Alkyl eromatics	22	Toluene, styrene, methylbiphenyl
Aldehydes end ketones	7 + (1)	(Benzaldehyde), acetophenone undecanal, fluorenone
Phthalate esters	5	
Acids	5	Dodecanoic acid, tetradecanoic acid
Unsaturated hydrocarbons	9	
Seturated and cyclic hydrocarbons	1	
Siloxanes	(4)	Not applicable
Unknowns	21	Not applicable

[a]Numbers and example compounds in parentheses are suspected to be background.

MONS 217745

Table B-26

SUMMARY OF PRODUCTS FOUND IN NOMEX 411 (m-PHENYLENEDIAMINE, ISOPHTHALIC ACID POLYMER)[a], 500°C PYROLYSI[b]

Class	Number	Examples
Chlorinated aromatics	(8)	(Chlorobenzene, dichlorobenzene)
Chlorinated aliphatics	2 + (1)	(Tetrachloroethylene), trichloropropane
Aromatic hydrocarbons	2	Pyrene, anthracene
Aldehydes and ketones	2	Acetophenone, fluorenone
Alcohols	1	Nonanol
Saturated and cyclic hydrocarbons	7	
Siloxanes	(8)	Not applicable
Unknowns	7	Not applicable

[a]Composition from E. L. Carson, M. D. Erickson, and J. L. McCann (Midwest Research Institute). Literature Review of Pyrolysis and Combustion Products of Selected Utility Materials. Palo Alto, CA: Electric Power Research Institute, November 1986. EPRI EL-4539.

[b]Numbers and example compounds in parentheses are suspected to be background.

MONS 217746

Table B-27

SUMMARY OF PRODUCTS FOUND IN NOMEX 411 (m-PHENYLENEDIAMINE, ISOPHTHALIC ACID POLYMER)[a], 900°C PYROLYSIS[b]

Class	Number	Examples
Chlorinated aromatics	(7)	(Chlorobenzene, trichlorobenzene)
Aromatic hydrocarbons	1 + (1)	(Benzene), pyrene
Alkyl aromatics	(1)	($C_{15}H_{16}$)
Aldehydes and ketones	1	Fluorenone
Phthalate esters	1	
Unsaturated hydrocarbons	3	Dimethylhexane
Saturated and cyclic hydrocarbons	6	
Siloxanes	(3)	Not applicable
Unknowns	7	Not applicable

[a]Composition from B. L. Carson, M. D. Erickson, and J. L. McCann (Midwest Research Institute). Literature Review of Pyrolysis and Combustion Products of Selected Utility Materials. Palo Alto, CA: Electric Power Research Institute, November 1986. EPRI EL-4939.

[b]Numbers and example compounds in parentheses are suspected to be background.

MONS 217747

Table B-28

SUMMARY OF PRODUCTS FOUND IN NOMEX 411 (m-PHENYLENEDIAMINE, ISOPHTHALIC ACID POLYMER)[a], 500°C COMBUSTION[b]

Class	Number	Examples
Chlorinated aromatics	(9)	(Chlorobenzene, dichlorobenzene)
Chlorinated aliphatics	1 + (1)	Chloroalkane, (tetrachloroethylene)
Nitrogen heterocycles	1	Isoindoledione
Aromatic hydrocarbons	3	Pyrene, anthracene, fluoranthene
Aldehydes and ketones	1 + (1)	Dimethylethylcyclohexandienedione, (benzaldehyde)
Phthalate esters	(1)	
Saturated and cyclic hydrocarbons	7	
Siloxanes	(6)	Not applicable
Unknowns	16	Not applicable

[a]Composition from B. L. Cerson, M. D. Erickson, and J. L. McCenn (Midwest Research Institute). Literature Review of Pyrolysis and Combustion Products of Selected Utility Materials. Palo Alto, CA: Electric Power Research Institute, November 1986. EPRI EL-4939.

[b]Numbers and example compounds in parentheses are suspected to be background.

MONS 217748

Teble B-29

SUMMARY OF PRODUCTS FOUND IN NOMEX 411 (m-PHENYLENEDIAMINE, ISOPHTHALIC ACID POLYMER)[a], 900°C COMBUSTION[b]

Class	Number	Examples
Chlorineted erometics	(9)	(Trichlorobenzene, chlorobenzene)
Nitrogen heterocycles	1	Isoindoledione
Aromatic hydrocarbons	3	Pyrene, anthracene, fluorenthene
Aldehydes end ketones	1	Fluorenone
Phthalate esters	1	
Unsaturated hydrocarbons	3	
Saturated end cyclic hydrocarbons	5	
Siloxanes	(6)	Not applicable
Unknowns	7	Not applicable

[a]Composition from B. L. Carson, M. D. Erickson, and J. L. McCenn (Midwest Research Institute). Literature Review of Pyrolysis end Combustion Products of Selected Utility Materials. Palo Alto, CA: Electric Power Reseerch Institute, November 1986. EPRI EL-4939.

[b]Numbers and example compounds in perentheses ere suspected to be background.

MONS 217749

Table B-30

SUMMARY OF PRODUCTS FOUND IN CREOSOTE, 500°C PYROLYSIS[a]

Class	Number	Examples
Nitrogen heterocycles	3	Isoquinoline, quinoline, C_2-alkylaniline
Oxygen heterocycles	1	Benzonaphthofuran
Aromatic hydrocarbons	11	Naphthalene, biphenyl, acenaphthene
Alkyl aromatics	17	$C_{11}H_{10}$, alkylnaphthalenes
Unsaturated hydrocarbons	1	
Siloxanes	(2)	Not applicable
Unknowns	9	Not applicable

[a]Numbers and example compounds in parentheses are suspected to be background.

MONS 217750

Table B-31

SUMMARY OF PRODUCTS FOUND IN CREOSOTE, 900°C PYROLYSIS[a]

Class	Number	Examples
Chlorinated aliphatics	(1)	(Tetrachloroethene)
Nitrogen heterocycles	1	Isoquinoline
Sulfur heterocycles	2	Dihydrobenzothiophene, methylbenzothiophene
Aromatic hydrocarbons	4	Biphenyl, acenaphthylene, anthracene
Alkyl aromatics	15	Methylnaphthalene, C_2-alkylnaphthalene
Saturated and cyclic hydrocarbons	2	
Siloxanes	(2)	Not applicable
Unknowns	10	Not applicable

[a]Numbers and example compounds in parentheses are suspected to be background.

MONS 217751

Table B-32

SUMMARY OF PRODUCTS FOUND IN CREOSOTE, 500°C COMBUSTION[a]

Class	Number	Examples
Chlorinated aromatics	(1)	(Dichlorobenzene)
Nitrogen heterocycles	2	Isoquinoline, quinoline,
Sulfur heterocycles	1	Benzothiophene
Oxygen heterocycles	3	Benzofuren, dibenzofuran, methyldibenzofuran
Aromatic hydrocarbons	10	Nephthalene, acenaphthene, anthracene
Alkyl aromatics	21	Methylnaphthalene, methylfuran, C_2-alkylnaphthalene
Unknowns	8	Not applicable

[a]Numbers and example compounds in parentheses are suspected to be background.

MONS 217752

Table B-33

SUMMARY OF PRODUCTS FOUND IN CREOSOTE, 900°C COMBUSTION[a]

Class	Number	Examples
Chlorineted aromatics	(1)	(Chlorobenzene)
Chlorinated aliphatics	(1)	(Tetrachloroethene)
Nitrogen hetarocycles	3	C_5-alkylpyridine, isoquinoline, methylquinoline,
Sulfur heterocycles	1	Benzothiophene
Oxygen heterocycles	3	Methyldibenzofuren
Aromatic hydrocarbons	9	Naphthalene, biphenyl, fluorene, anthracene
Alkyl aromatics	8	Methylnaphthelene, C_2-alkylnaphthalene
Saturated end cyclic hydrocarbons	1	Not applicable
Siloxanes	(2)	Not applicable
Unknowns	13	Not applicable

[a]Numbers and example compounds in parentheses are suspected to be background.

MONS 217753

Table B-34

SUMMARY OF PRODUCTS FOUND IN MAPLE WOOD, 500°C PYROLYSIS[a]

Class	Number	Examples
Nitriles	1	Pentadiene nitrile
Oxygen heterocycles	1	Dihydropyran
Phenols and other hydroxy aromatics	7	Methoxymethylphenol, dimethoxypropenyl phenol
Aromatic hydrocarbons	1 + (1)	(Biphenyl)
Alkyl aromatics	1	Styrene
Aldehydes and ketones	3	Nonanal
Alcohols + ethers	2	Trimethoxybenzene
Phthalate esters	4	
Other esters	1	Methyl tetradecanoate
Acids	6	Acetic acid, tetradecanoic acid
Unsaturated hydrocarbons	9	
Saturated and cyclic hydrocarbons	4	
Siloxanes	(10)	Not applicable
Unknowns	19	Not applicable

[a]Numbers and example compounds in parentheses are suspected to be background.

MONS 217754

Table B-35

SUMMARY OF PRODUCTS FOUND IN MAPLE WOOD, 900°C PYROLYSIS[a]

Class	Number	Examples
Chlorinated aromatics	(1)	(Chlorobenzene)
Chlorinated aliphatics	(1)	(Dichloroethelene)
Oxygen heterocycles	3	Methylfuran, dimethylfuran, methylbenzofuran
Phenols and other hydroxy aromatics	6	Eugenol, hydroxydimethoxybenzaldehyde
Aromatic hydrocarbons	4 + (1)	Naphthalene, biphenyl, indene, fluorene, (benzene)
Alkyl aromatics	21 + (1)	Alkylbenzenes, alkylbiphenyls, alkylindenes, (toluene)
Aldehydes and ketones	3	Hydroxymethylcyclopentenone, acetophenone, benzaldehyde
Alcohols	2	Heptadecanol, $C_{12}H_{26}O$
Phthalate esters	2	Dioctyl phthalate
Carboxylic acids	6	Benzoic, dodecanoic, hexadecanoic acids
Unsaturated hydrocarbons	10	C_8H_{16}, $C_{11}H_{22}$
Saturated and cyclic hydrocarbons	9	C_8H_{18}
Siloxenes	(6)	Not applicable
Unknowns	13	Not applicable

[a]Numbers and example compounds in parentheses are suspected to be background.

MONS 217755

Table B-36

SUMMARY OF PRODUCTS FOUND IN MAPLE WOOD, 500°C COMBUSTION[a]

Class	Number	Examples
Chlorinated aromatics	(1)	(Chlorophenol)
Chlorinated aliphatics	(1)	(Chloroalkane)
Nitriles	2	Tetradecane nitrile, benzonitrile
Oxygen heterocycles	1	Furancarboxaldehyde
Phenols and other hydroxy aromatics	5	Phenol, hydroxybenzaldehyde
Aromatic hydrocarbons	3 + (1)	(Benzene), dihydroindenone
Alkyl aromatics	5	Styrene, C_8-alkenylbenzene
Aldehydes and ketones	13	Benzaldehyde, decenal
Phthelate esters	3	Diethyl phthalate
Other esters	2	Methyl benzoate
Acids	5	Benzocarbothioic acid, benzoic acid, decanoic acid
Unsaturated hydrocarbons	7	
Saturated and cyclic hydrocarbons	1	
Siloxanes	(4)	Not applicable
Unknowns	29	Not applicable

[a]Numbers and example compounds in parentheses are suspected to be background.

MONS 217756

Table B-37

SUMMARY OF PRODUCTS FOUND IN MAPLE WOOD, 900°C COMBUSTION[a]

Class	Number	Examples
Chlorinated aromatics	(3)	(Chlorobenzene)
Chlorinated aliphatics	(1)	(Dichloroethene)
Oxygen heterocycles	3	Dibenzofuran, furan-carboxaldehyde
Phenols and other hydroxy aromatics	6	Phenol, hydroxymethoxy-benzaldehyde
Aromatic hydrocarbons	2 + (1)	(Benzene), naphthalene
Alkyl aromatics	2	Styrene, C_8-alkylbenzene
Aldehydes and ketones	17	Benzaldehyde, octanal
Phthalate esters	2	
Other esters	3	Methyl acetate
Acids	4	Nonanoic acid
Unsaturated hydrocarbons	9	
Saturated and cyclic hydro-carbons	3	
Siloxanes	(4)	Not applicable
Unknowns	19	Not applicable

[a]Numbers and example compounds in parentheses are suspected to be background.

MONS 217757

Table B-38

SUMMARY OF PRODUCTS FOUND IN KRAFT PAPER (TOR-2), 500°C PYROLYSIS[a]

Class	Number	Examples
Chlorinated aliphatics	(1)	(Dichloroethene)
Nitriles	1	Alkylnitrile
Oxygen heterocycles	4	Methylfuran, dimethylfuran
Aromatic hydrocarbons	1 + (1)	(Benzene), C_8H_8
Alkyl aromatics	(1)	($C_{15}H_{16}$)
Aldehydes and ketones	9	Furancarboxaldehyde, methyl-butenal, tetradecanal
Phthalate esters	2	
Other esters	1	Dioctyladipate
Acids	8	Hexadecanoic acid, acetic acid
Unsaturated hydrocarbons	7	Alkenes
Seturated and cyclic hydrocarbons	6	Alkanes
Siloxanes	11	Not applicable
Unknowns	34	Not applicable

[a]Numbers and example compounds in parentheses are suspected to be background.

MONS 217758

Table B-39

SUMMARY OF PRODUCTS FOUND IN KRAFT PAPER (TOR-2), 900°C PYROLYSIS[a]

Class	Number	Examples
Chlorinated aliphatics	(1)	(Chlorobenzene)
Aromatic hydrocarbons	4 + (2)	(Benzene), naphthalene, fluorene
Alkyl aromatics	13 + (1)	(Toluene), methylindene, styrene
Aldehydes and ketones	3 + (1)	Acetophenone, nonanal
Phthalate esters	2	
Acids	3	Tetredecanoic acid
Unsaturated hydrocarbons	7	
Saturated and cyclic hydrocarbons	13	
Siloxanes	13	Not applicable
Unknowns	17	Not applicable

[a]Numbers and example compounds in parentheses are suspected to be background.

MONS 217759

Table B-40

SUMMARY OF PRODUCTS FOUND IN KRAFT PAPER (TOR-2), 500°C COMBUSTION[a]

Class	Number	Examples
Nitriles	1	Benzonitrile
Oxygen heterocycles	2	Furancarboxaldehyde
Phenols and other hydroxy aromatics	2	Phenol, hydroxybenzeldehyde
Aromatic hydrocarbons	1 + (3)	Biphenyl, (benzene)
Alkyl aromatics	3	Styrene, $C_{15}H_{16}$
Aldehydes and ketones	12 + (2)	Heptanal, acetophenone, undecanal
Phthalate esters	2	
Acids	8	Acetic acid, dodecanoic acid
Unsaturated hydrocarbons	3	
Siloxanes	(9)	Not applicable
Unknowns	18	Not applicable

[a]Numbers and example compounds in parentheses are suspected to be background.

MONS 217760

Table 8-41

SUMMARY OF PRODUCTS FOUND IN KRAFT PAPER (TOR-2), 900°C COMBUSTION[a]

Class	Number	Examples
Chlorinated aromatics	(2)	(Chlorobenzene)
Oxygen heterocycles	4	Benzofuren, methylbenzofuran, dibenzofuren
Phenols and other hydroxy aromatics	2	Phenol, methylphenol
Aromatic hydrocarbons	8 + (1)	(Benzene), naphthalene, biphenyl
Alkyl aromatics	18	Toluene, styrene, C_3-alkenyl-benzene
Aldehydes and ketones	6 + (1)	(Benzeldehyde), nonenal dihydro-indenone, fluorenone
Phthalate esters	4	
Acids	4	Dodecanoic acid, tetradecanoic acid
Unsaturated hydrocarbons	3	
Siloxanes	(6)	Not applicable
Unknowns	21	Not applicable

[a]Numbers and example compounds in parenthesas are suspected to be background.

MONS 217761

Table B-42

SUMMARY OF PRODUCTS FOUND IN RAG PAPER (TOR-3), 900°C PYROLYSIS[a]

Class	Number	Examples
Oxygen heterocycles	7	Methylfurans, furanylethanone
Phenols and other hydroxy aromatics	4	Cresol, xylenol, eugenol
Aromatic hydrocarbons	1+(1)	Indene, (benzene)
Alkyl aromatics	4+(1)	Methyl styrene, dimethyl naphthalene, (toluene)
Aldehydes and ketones	6	Methylcyclopentenone, octanone, benzaldehyde
Other esters	1	Unknown ester
Carboxylic acids	2	Hexadecanoic acid, octadecanoic acid
Unsaturated hydrocarbons	2	C_8H_8, C_8H_{14}
Saturated and cyclic hydrocarbons	1	Alkane
Siloxanes	(2)	Not applicable
Unknowns	28	Not applicable

[a]Numbers and example compounds in parentheses are suspected to be background.

Table B-43

SUMMARY OF PRODUCTS FOUND IN KRAFT PRESSBOARD (TOR-5), 900°C PYROLYSIS[a]

Class	Number	Examples
Oxygen heterocycles	8	Methylfurans, methylfurfural, methylbenzofuran, hydroxymethylpyranone
Phenols and other hydroxy aromatics	6	Phenol, methylphenols, ethylbenzenediol, eugenol
Aromatic hydrocarbons	(1)	(Benzene)
Alkyl aromatics	4+(1)	Methylindene, methylnaphthalene
Aldehydes and ketones	9	Benzaldehyde, bicyclohexanone, acetophenone
Carboxylic acids	1	Hexadecanoic acid
Unsaturated hydrocarbons	4	Cyclohexadiene, methylpentene
Siloxanes	(5)	Not applicable
Unknowns	34	Not applicable

[a]Numbers and example compounds in parentheses are suspected to be background.

MONS 217763

Table B-44

SUMMARY OF PRODUCTS FOUND IN 35 KV CABLE-CPE[a] INSULATION, 500°C PYROLYSIS[b]

Class	Number	Examples
Oxygen heterocycles	1	Methylfuran
Acids	5	Tetradecanoic acid, hexadecanoic acid
Unsaturated hydrocarbons	5	
Saturated and cyclic hydrocarbons	5	
Siloxenes	(8)	Not applicable
Unknowns	3	Not applicable

[a]Cross-linked polyethylene.

[b]Numbers and example compounds in parentheses are suspected to be background.

MONS 217764

Table B-45

SUMMARY OF PRODUCTS FOUND IN 35 KV CABLE-CPE[a] INSULATION, 900°C PYROLYSIS[b]

Class	Number	Examples
Oxygen heterocycles	1	Methylbenzofuran
Phenols and other hydroxy aromatics	3	Propenyloxymethylbenzene, ethylideneindene
Aromatic hydrocarbons	4	Indene, biphanyl
Alkyl aromatics	22	Styrene, C_3-alkenylbenzene, ethylideneindene
Aldehydes and ketones	1 + (1)	(Benzaldehyde), dihydroindenone, alkenals
Phthalate esters	1	
Other esters	1	Alkylpropanoic acid ester
Unsaturated hydrocarbons	16	Alkenes, alkadienes
Saturated and cyclic hydrocarbons	9	Alkanes
Unknowns	12	Not applicable

[a]Cross-linked polyethylene.

[b]Numbers and example compounds in parentheses are suspected to be background.

MONS 217765

Table B-46

SUMMARY OF PRODUCTS FOUND IN 35 KV CABLE-CPE[a] INSULATION, 500°C COMBUSTION[b]

Class	Number	Examples
Chlorinated aromatics	(1)	Chlorobenzene
Oxygen heterocycles	1	Dibenzofuran
Phenols and other hydroxy aromatics	1	Hydroxybenzaldehyde
Aromatic hydrocarbons	2 + (1)	(Benzene), C_6H_6, biphenyl
Alkyl aromatics	3 + (1)	Toluene, styrane, C_3-alkylphenanthrene
Aldehydes and ketones	6 + (1)	Heptanal, acatophenone, dodecanal
Alcohols	1	Alkanol
Phthalate esters	3	
Acids	5	Tetradecanoic, hexadecanoic acid
Unsaturated hydrocarbons	5	
Saturated and cyclic hydrocarbons	4	
Siloxanes	(3)	Not applicable
Unknowns	11	Not applicable

[a]Cross-linked polyethylene.

[b]Numbers and example compounds in parentheses are suspected to be background.

MONS 217766

Table B-47

SUMMARY OF PRODUCTS FOUND IN 35 KV CABLE-CPE[a] INSULATION, 900°C COMBUSION[b]

Class	Number	Examples
Chlorinated aromatics	(1)	(Chlorobenzene)
Phenols and other hydroxy aromatics	1	Phenol
Aromatic hydrocarbons	(1)	(Benzene)
Alkyl aromatics	1	C_3-alkenylbenzene
Aldehydes and ketones	9 + (1)	(Benzaldehyde), nonanal, tridecanal
Phthalate esters	4	
Other esters	1	Triphenyl, phosphate
Acids	5	Tetradecanoic acid
Unsaturated hydrocarbons	3	Alkenes
Saturated and cyclic hydrocarbons	12	Alkanes
Siloxanes	5	Not applicable
Unknowns	7	Not applicable

[a]Cross-linked polyethylene.

[b]Numbers and example compounds in parentheses are suspected to be background.

MONS 217767

Table B-48

SUMMARY OF PRODUCTS FOUND IN MIOEL 7131 (PENTAERYTHRITOL ALIPHATIC AND AROMATIC ESTERS)[a], 500°C PYROLYSIS[b]

Class	Number	Examples
Chlorinated aliphatics	(3) + 3	Dichlorobutene (tetrachloroethylene)
Nitriles	1	Heptane nitrile
Oxygen heterocycles	1	Methylfuran
Aromatic hydrocarbons	2 + (1)	(Benzene), dihydronaphthalene
Alkyl aromatics	6 + (3)	(Toluene, C_3-alkyl biphenyl), xylene, styrene
Aldehydes and ketones	6	Heptanal, octanone, pentadecanone
Esters	3	Methyl heptanoate, methyl octanoate
Acids	1	Nonanoic acid
Unsaturated hydrocabons	4	Dimethylheptyne
Saturated and cyclic hydrocerbons	4	
Unknowns	27	Not applicable

[a]Composition from J. V. Zbozinek, J. R. Marsh, D. Guth, and A. Bohrnerud (SCS Engineers, Inc.). State-of-the-Art Review of Combustion and Pyrolysis By-Products of PCB Substitutes. Palo Alto, CA: Electric Power Research Institute, March 1986. EPRI EL-4503.

[b]Numbers and example compounds in parentheses are suspected to be background.

MONS 217768

Table B-49

SUMMARY OF PRODUCTS FOUND IN MIDEL 7131 (PENTAERYTHRITOL ALIPHATIC AND AROMATIC ESTERS)[a], 900°C PYROLYSIS[b]

Class	Number	Examples
Chlorinated aliphatics	(1)	(Tetrachloroethylene)
Phenols and other hydroxy aromatics	1	C_9-Alkyl phenol
Aromatic hydrocarbons	2 + (1)	(Benzene), indene, fluorene
Alkyl aromatics	9 + (3)	(Toluene), xylene, (C_3-alkyl biphenyls)
Aldehydes and ketones	6	Nonanone, Tridecanone
Esters	2	Methyl heptanoate, methyl octanoate
Acids	3	Benzoic acid, dodecanoic acid
Unsaturated hydrocabons	1	Methylpropylidene cyclopentane
Saturated and cyclic hydrocarbons	1	
Siloxanes	(3)	Not applicable
Unknowns	15	Not applicable

[a]Composition from J. V. Zbozinek, J. R. Marsh, D. Guth, and A. Bohrnerud (SCS Engineers, Inc.). State-of-the-Art Review of Combustion and Pyrolysis By-Products of PCB Substitutes. Palo Alto, CA: Electric Power Research Institute, March 1986. EPRI EL-4503.

[b]Numbers and example compounds in parentheses are suspected to be background.

MONS 217769

Table B-5D

SUMMARY OF PRODUCTS FOUND IN MIDEL 7131 (PENTAERYTHRITOL ALIPHATIC AND AROMATIC ESTERS)[a], 500°C COMBUSTION[b]

Class	Number	Examples
Chlorinated aliphatics	(1) + 1	(Tetrechloroethylene), dichlorobutene
Phenols and other hydroxy eromatics	2	Phenol, methyl phenol
Aromatic hydrocarbons	(1)	(Benzene)
Alkyl aromatics	(2)	(C_3-alkyl biphenyl)
Aldehydes and ketones	6	Heptanal, methylcyclo-pentanone
Acid anhydrides	1	Acetic acid anhydride
Esters	1	Methyl heptanoate
Acids	3	Acetic acid, benzoic acid, alkanoic acid
Unsaturated hydrocabons	1	C_9-alkene
Siloxanes	(2)	Not applicable
Unknowns	14	Not applicable

[a]Composition from J. V. Zbozinek, J. R. Marsh, D. Guth, and A. Bohrnerud (SCS Engineers, Inc.). State-of-the-Art Review of Combustion and Pyrolysis By-Products of PCB Substitutes. Palo Alto, CA: Electric Power Research Institute, March 1986. EPRI EL-4503.

[b]Numbers and example compounds in parentheses are suspected to be background.

MONS 217770

Table B-51

SUMMARY OF PRODUCTS FOUND IN WEMCOL FLUID (ISOPROPYLBIPHENYL)[a], 500°C PYROLYSIS

Class	Number	Examples
Aromatic hydrocarbons	2 + (1)	(Banzene), biphenyl, $C_{14}H_{10}$
Alkyl aromatics	18 + (1)	(Toluene), methyl indene, dimethyl fluorene
Aldehydes and ketones	3	Biphenyl-yl-ethanone, fluorenone, C_3-alkylbiphenyl
Unsaturated hydrocarbons	1	C_8H_8
Saturated and cyclic hydrocarbons	2	
Siloxanes	(1)	Not applicable
Unknowns	3	Not applicable

[a]Composition from J. V. Zbozinek, J. R. Marsh, D. Guth, and A. Bohrnerud (SCS Engineers, Inc.). State-of-the-Art Review of Combustion and Pyrolysis By-Products of PCB Substitutes. Palo Alto, CA: Electric Power Research Institute, March 1986. EPRI EL-4503.

[b]Numbers and example compounds in parentheses are suspected to be background.

MONS 217771

Table 8-52

SUMMARY OF PRODUCTS FOUND IN WEMCOL FLUID (ISOPROPYLBIPHENYL)[a], 500°C COMBUSTION[b]

Class	Number	Examples
Chlorinated aromatics	(1)	(Trichlorobenzene)
Aromatic hydrocarbons	2 + (1)	(Benzene), biphenyl, $C_{14}H_{10}$
Alkyl aromatics	6	C_3-Alkenyl biphenyl, $C_{18}H_{22}$
Aldehydes and ketones	6	Benzaldehyde, fluorenone
Unsaturated hydrocarbons	1	C_8H_8
Unknowns	8	Not applicable

[a]Composition from J. V. Zbozinek, J. R. Marsh, D. Guth, and A. Bohrnerud (SCS Engineers, Inc.). State-of-the-Art Review of Combustion and Pyrolysis By-Products of PCB Substitutes. Palo Alto, CA: Electric Power Research Institute, March 1986. EPRI EL-4503.

[b]Numbers and example compounds in parentheses are suspected to be background.

NONS 217772

Table B-53

SUMMARY OF PRODUCTS FOUND IN WEMCOL FLUID (ISOPROPYLBIPHENYL)[a], 900°C COMBUSTION[b]

Class	Number	Examples
Chlorinated aromatics	2 + (3)	(Chlorobenzene), dichlorophenol
Oxygen heterocycles	1	Methyl benzofuran
Phenols and other hydroxy aromatics	1	C_3-Alkyl phenol
Aromatic hydrocarbons	4	Indene, $C_{10}H_8$, biphenyl
Alkyl aromatics	18 + (1)	(Toluene), propadienyl, benzene, C_3-alkylbiphenyl
Aldehydes and ketones	11	Phenylethanone, nonanal, $C_{10}H_{12}O$
Unsaturated hydrocarbons	3	Hexadecene
Saturated and cyclic hydrocarbons	3	Cycloalkane
Siloxanes	(2)	Not applicable
Unknowns	6	Not applicable

[a]Composition from J. V. Zbozinek, J. R. Marsh, D. Guth, and A. Bohrnerud (SCS Engineers, Inc.). State-of-the-Art Review of Combustion and Pyrolysis By-Products of PCB Substitutes. Palo Alto, CA: Electric Power Research Institute, March 1986. EPRI EL-4503.

[b]Numbers and example compounds in parentheses are suspected to be background.

MONS 217773

Table B-54

SUMMARY OF PRODUCTS FOUND IN EOISOL III (C_3-ALKYLBIPHENYLS AND PHENYLXYLYLETHANE), 500°C PYROLYSIS[a]

Class	Number	Examples
Chlorinated aromatics	(3)	(Dichlorobenzene)
Oxygen heterocycles	1	Benzofuran
Aromatic hydrocarbons	3	Biphenyl
Alkyl aromatics	29	Methylstyrene, $C_{18}H_{16}$
Aldehydes and ketones	1	Acetophenone
Alcohols	2	Ethyloctynol
Unsaturated hydrocarbons	10	Octane, C_7H_{10}
Saturated and cyclic hydrocarbons	1	Unidentified
Siloxanes	(5)	Not applicable
Unknowns	14	Not applicable

Source: Table 4, Pyrolysis and Combustion of Utility Materials. Quarterly Report No. 3, EPRI Contract No. RP 2028-16, August 8, 1986, Barry Dellinger, University of Dayton Research Institute.

[a]Numbers and example compounds in parentheses are suspected to be background.

MONS 217774

Table B-55

SUMMARY OF PRODUCTS FOUND IN EDISOL III (C_3-ALKYLBIPHENYLS AND PHENYLXYLYLETHANE), 900°C PYROLYSIS[a]

Class	Number	Examples
Chlorinated aromatics	1+(2)	Chlorotoluene, (chlorobenzenes)
Oxygen heterocycles	1	Benzofuran
Phenols and other hydroxy aromatics	1	Cresol
Aromatic hydrocarbons	4+(1)	Biphenyl, benzonitrile, naphthalene, dihydronaphthalene, (benzene)
Alkyl aromatics	50+(1)	Methyleneindene, styrene, methylbiphenyl, (toluene)
Aldehydes and ketones	3	Benzaldehyde, C_9H_8O
Unsaturated hydrocarbons	12	Cyclohexadiene, 1,3,5-cycloheptatriene
Saturated and cyclic hydrocarbons	3	Ethylcyclohexane
Siloxanes	(5)	Not applicable
Unknowns	9	Not applicable

Source: Table 4, Pyrolysis and Combustion of Utility Materials. Quarterly Report No. 3, EPRI Contract No. RP 2028-16, August 8, 1986, Barry Dellinger, University of Dayton Research Institute.

[a]Numbers and example compounds in parentheses are suspected to be background.

MONS 217775

Table B-56

SUMMARY OF PRODUCTS FOUND IN EDISOL III (C_3-ALKYLBIPHENYLS AND PHENYLXYLYLETHANE), 500°C COMBUSTION[a]

Class	Number	Examples
Chlorinated aromatics	(8)	Tetrachloroethylene, (pentachlorobenzene)
Chlorinated aliphatics	1	
Oxygen heterocycles	2	Benzofuran
Aromatic hydrocarbons	3	Biphenyl
Alkyl aromatics	30	Dimethylfluorene
Aldehydes and ketones	8	Benzaldehyde, dimethylbenzophenone
Alcohols	1	Unidentified
Unsaturated hydrocarbons	10	
Siloxanes	(4)	Not applicable
Unknowns	21	Not applicable

Source: Table 4, Pyrolysis and Combustion of Utility Materials. Quarterly Report No. 3, EPRI Contract No. RP 2028-16, August 8, 1986, Barry Dellinger, University of Dayton Research Institute.

[a]Numbers and example compounds in parentheses are suspected to be background.

MONS 217776

Table B-57

SUMMARY OF PRODUCTS FOUND IN EOISOL III (C_3-ALKYLBIPHENYLS AND PHENYLXYLYLETHANE), 900°C COMBUSTION[a]

Class	Number	Examples
Chlorinated aromatics	2 + (5)	Chloroxylene, chlorotoluene, (chlorobenzenes)
Chlorinated aliphatics	1	Tetrachloroethylene
Oxygen heterocycles	1	Benzofuran
Aromatic hydrocarbons	5+(1)	Naphthalene, biphenyl, indene, (benzene)
Alkyl aromatics	26+(1)	Alkylbenzenes, alkylbiphenyls, (toluene)
Aldehydes and ketones	5	Benzaldehyde, alkylbenzaldehydes, cyclohexenecerboxaldehyde
Alcohols	1	Ethyloctynol
Unsaturated hydrocarbons	7	C_7H_{10}, methylethylidenecyclopentediene
Siloxenes	(4)	Not applicable
Unknowns	8	Not appliceble

Source: Teble 4, Pyrolysis and Combustion of Utility Materials. Quarterly Report No. 3, EPRI Contract No. RP 2028-16, August 8, 1986, Barry Dellinger, University of Dayton Research Institute.

[a]Numbers end example compounds in parentheses are suspected to be background.

MONS 217777

Table B-58

SUMMARY OF PRODUCTS FOUND IN FORMEX WIRE ENAMEL (TOR-8), 900°C PYROLYSIS[a]

Class	Number	Examples
Nitrogen heterocycles	1	Mathylpyrazole
Phenols and other hydroxy aromatics	7	Phenol, C_2-alkylphenol
Aromatic hydrocarbons	1+(1)	(Benzene), dihydroindene
Alkyl aromatics	25	C_3-Alkylbenzene, C_4-alkylbenzene, methyleneindene
Aldehydes and ketones	1	Phenylbutanone
Phthalate esters	2	Diethyl phthalate
Other esters	3	Phenyl carbamate, phenyl butenoate
Acids	1	Hexadecanoic acid
Unsaturated hydrocarbons	2	Pentyne
Saturated and cyclic hydrocarbons	2	C_8H_8, trimethylcyclopentane
Siloxanes	(1)	Not appliceble
Unknowns	45	Not appliceble

[a]Numbers and example compounds in parentheses are suspected to be background.

MONS 217778

Table B-59

SUMMARY OF PRODUCTS FOUND IN KRAFT PHENOLIC LAMINATE (HERKOLITE, TOR-6), 900°C PYROLYSIS[a]

Class	Number	Examples
Nitrogen heterocycles	8	Ethylmethylpyrrolidine, acridine
Amines	1	Naphthalenamine
Oxygen heterocycles	2	Methylfuran, xenthene
Phenols and other hydroxy aromatics	12	Cresol, C_2-alkylphenol
Aromatic hydrocarbons	(1)	(Benzene)
Alkyl aromatics	2 + (1)	C_3-Alkylbenzene, (toluene)
Aldehydes and ketones	5	Ethenylbutenal, methylphenylbutenone
Alcohols	1	Methyl(methylethyl)cyclohexanol
Siloxanes	(2)	Not applicable
Unknowns	5	Not applicable

[a]Numbers and example compounds in parentheses are suspected to be background.

MONS 217779

Table B-60

SUMMARY OF PRODUCTS FOUND IN KRAFT PHENOLIC LAMINATE (SPAULDITE, TOR-7), 900°C PYROLYSIS[a]

Class	Number	Examples
Nitrogen heterocycles	5	Acridine, methylphenylindole
Oxygen heterocycles	3	Methylfuranone, dimethylbenzofuran, xanthene
Phenols and other hydroxy aromatics	16	Phenol; hydroxybenzaldehyde, trimethoxybenzene
Aromatic hydrocarbons	(1)	(Benzene)
Alkyl aromatics	5+(1)	Ethylbenzene, $C_{11}H_{10}$, $C_{14}H_{14}$, (toluene)
Aldehydes and ketones	2	Methylbutenal, methylphenylbutenone
Alcohols	1	Unknown alcohol
Phthalate esters	1	Unknown phthalate ester
Carboxylic acids	1	Dodecanoic acid
Saturated and cyclic hydrocarbons	1	C_8H_{10}
Siloxanes	(3)	Not applicable
Unknowns	16	Not applicable

[a]Numbers and example compounds in parentheses are suspected to be background.

MONS 217780

