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US High Production Volume Chemical Program

Category Summary

For

Resin Oils and Cyclodiene Dimer Concentrates Category

Prepared by:

Olefins Panel of the American Chemistry Council

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EXECUTIVE SUMMARY

The Olefins Panel of the American Chemistry Council (ACC) hereby submits the category summary report for the Resin Oils and Cyclodiene Dimer Concentrates Category under the US Environmental Protection Agency's High Production Volume (HPV) Chemical Challenge Program. The purpose of this report is to:

- Present results of an assessment to determine whether the 10 CAS numbers that represent 9 production streams are adequately characterized with the existing data from representative streams and hydrocarbon constituents of the process streams as described in the Resin Oils and Cyclodiene Dimer Concentrates Category test plan.

- Summarize the SIDS (Screening Information Data Set) physicochemical, environmental fate and effects, and human health HPV program endpoints for the Resin Oils and Cyclodiene Dimer Concentrates Category.

- Provide a description of manufacturing processes, potential exposure sources, and uses for Resin Oils and Cyclodiene Dimer Concentrates.

- Demonstrate that the extensive body of data available for mammalian and environmental endpoints on representative streams and constituents of the process streams within the category are sufficient to fully define the Resin Oils and Cyclodiene Dimer Concentrates Category.

The Resin Oils and Cyclodiene Dimer Concentrates Category is comprised of 9 related petrochemical process streams derived from pyrolysis gasoline by the ethylene manufacturing process. The 10 CAS numbers in this category each represent at least one production stream but may be present in more than one stream. The streams that form this category are complex mixtures of C4-C12 hydrocarbons, comprised primarily of C8 to C12 aliphatic cycloalkenes, and aromatic hydrocarbons of which dicyclopentadiene (DCPD) is a key chemical component in the majority of streams. All but 2 of the streams contain amounts of DCPD greater than 1%. One stream, Low DCPD Resin Oil, contains insignificant amounts of DCPD in a matrix of C8 to C12 aromatic and cycloalkene hydrocarbons. Methylcyclopentadiene Dimer (MCPD Dimer) is also a stream with little DCPD, because it is processed to maximize MCPD Dimer content.

Exposure

The primary uses of streams in the Resin Oils and Cyclodiene Dimer Concentrates Category are as reactive intermediates in the production of resins, or blended with other streams to produce fuel oils. Resin oils account for 56% of production with Cyclodiene Dimer Concentrates comprising the balance. There are no consumer uses expected for the streams in this category because they are used only as intermediates. Production is performed in closed systems and products are transported in bulk in closed systems by pipeline, barge, tank car or tank truck. The streams are typically inventoried in bulk storage tanks, either floating roof or fixed roof with vents routed to a control device in order to reduce emissions. The most likely routes of human exposure are inhalation of vapors generated from evaporation, dermal contact, or possible oral ingestion from ground water contamination following a spill. However, since streams are transferred between industrial sites, stored and used inside closed systems, the possibility of occupational and public exposure to Resin Oils and Cyclodiene Dimer Concentrates is very low. Moreover, the category streams are mixtures of volatile organic compounds (VOC) and are therefore subject to USEPA and state environmental regulations that limit VOC emissions. Streams or components of these streams are slightly soluble in water, and groundwater contamination is possible if spills or leaks occur from production, transportation, or storage equipment.

Human Health

For toxicological evaluation, the 9 product streams in this category were divided into 3 subcategories based on the content of aliphatic cycloalkenes and aromatic components. Subcategory 1 contained 6 streams with high aliphatic content (98-99+%) – DCPD, High purity, DCPD Concentrate, MCPD Dimer, DCPD Purge Stream, DCPD/Codimer concentrate and DCPD stream. Subcategory 2 contained 2 streams that were 39-70% aliphatics and 30-65% aromatics - High DCPD Resin Oil and Resin Former Feedstock. Subcategory 3 contained a stream with low DCPD content (<5%) and high aromatic content (95%)- Low DCPD Resin Oil. Testing was performed on representative streams of subcategory 1 and 3 to determine if extremes of the category ranges yielded significantly different toxicological effects. Results of these studies evaluated with available data on other streams and selected chemicals that are present in these streams have made it possible to develop a toxicological and environmental profile of the Resin Oils and Cyclodiene Dimer Concentrates Category.

The streams of the Resin Oils and Cyclodiene Dimer Concentrates Category demonstrated minimal to mild acute toxicity regardless of chemical component distribution. None of the streams induced significant genetic toxicity *in vitro* or *in vivo*. A similar spectrum of subchronic toxicological effects was demonstrated by all tested streams by any route of exposure and included mild neurological effects during treatment, changes in body weight and feed consumption, and organ effects in kidney, liver, and thyroid. Male rats demonstrated the species and sex-specific hydrocarbon-induced hyaline droplet increases in the kidney with and without overt nephopathy, a syndrome considered not to be relevant to human health hazard (USEPA, 1991). Overall reproductive parameters were unaffected by exposure to representative resin oils and cyclodiene dimer concentrates; developmental effects were expressed primarily as low pup weight at birth and during lactation, and low pup weight gain and usually occurred when maternal weight was also affected. Differences in degree of toxic responses, which correlated with chemical composition were evident, particularly for developmental effects, and appeared to be related to and predictable from DCPD and MCPD Dimer levels in the process streams.

Environmental

For environmental endpoints, measured data on representative process streams, data on components present in the streams in this category, and data on other complex products that contain a similar range of chemical classes and carbon numbers were used. The hydrocarbons that comprise this category have a very low potential to hydrolyze and do not photodegrade directly due to a minimal capacity to absorb appreciable light energy above 290nm. However, atmospheric oxidation constitutes a significant route of degradation. Calculation of atmospheric half-lives of representative constituent chemicals identified a range of 0.7 to 53.0 hours as a result of indirect hydrolysis by hydroxyl radical attack. Fugacity modelling demonstrated that members of this category partition primarily into the air, or into air, soil and water, and minimal partitioning into sediment. These products do not biodegrade readily and have the potential to produce a high to moderate level of toxicity in freshwater algae and a high to moderate level of acute toxicity in freshwater fish and invertebrates.

Conclusions

The extensive body of data available for mammalian and environmental endpoints on selected constituents of products in this category, and on representative process streams of the Resin Oils and Cyclodiene Dimer Concentrates Category, are sufficient to fully characterize the potential toxicity for materials in this category and demonstrate the integrity of the category for purposes of the HPV program. No additional testing is needed to meet the requirements of the HPV program.

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CATEGORY DESCRIPTION AND JUSTIFICATION

1.1 Category Identification

The Resin Oils and Cyclodiene Dimer Concentrates Category was developed for the HPV program by grouping 9 related petrochemical process streams derived from distillation, and in some cases thermal processing, and further purification of the pyrolysis gasoline stream from the ethylene process unit. The 10 CAS numbers listed in Table 1 describe 9 streams which are complex products containing many components. Certain single streams are correctly represented by more than a single CAS number and a CAS number may be applicable to more than a single stream. A description of the ethylene production process is included in Appendix 1.

The streams that form this category are complex mixtures of C4-C12 hydrocarbons, comprised primarily of C8 to C12 aliphatic cycloalkenes, and aromatic hydrocarbons of which dicyclopentadiene (DCPD) is a key chemical component in the majority of streams. All but 2 of the streams contain amounts of DCPD greater than 1%. One stream, Low DCPD Resin Oil, contains insignificant amounts of DCPD in a matrix of C8 to C12 aromatic and cycloalkene hydrocarbons. Methylcyclopentadiene Dimer (MCPD Dimer) is also a stream with little DCPD, processed to maximize MCPD Dimer content.

The CAS Numbers in the Resin Oils and Cyclodiene Dimer Concentrates Category are associated with the following streams.

Table 1. CAS Numbers[1] and CAS Names Associated with Streams in the Resin Oils & Cyclodiene Dimer Concentrates Category

Production Streams	CAS RN	CAS RN Name
High DCPD Resin Oil	68477-54-3	Distillates, petroleum, steam-cracked, C8-12 fraction
	68477-40-7	Distillates, petroleum, cracked stripped steam-cracked petroleum distillates, C10-12 fraction
Low DCPD Resin Oil	68477-54-3	Distillates, petroleum, steam-cracked, C8-12 fraction
	68516-20-1	Naphtha, petroleum, steam-cracked middle arom.
Resin Former	68477-54-3	Distillates, petroleum, steam-cracked, C8-12 fraction
DCPD Concentrate	68478-08-0	Naphtha, petroleum, light steam-cracked, C5-fraction, oligomer conc.
	68527-26-4	Naphtha, petroleum, light steam-cracked, debenzenized
	68603-02-1	Distillates, petroleum, thermal cracked naphtha and gas oil, dimerized
DCPD, High Purity	77-73-6	4,7-Methano-1H-indene, 3a,4,7,7a-tetrahydro-
DCPD Purge Stream	68527-24-2	Naphtha, petroleum, light steam-cracked arom., C5-12 cycloalkadiene fraction, polymers
MCPD Dimer	26472-00-4	4,7-Methano-1H-indene, 3a,4,7,7a-tetrahydrodimethyl-
DCPD Stream	68477-53-2	Distillates, petroleum, steam-cracked, C5-12 fraction
DCPD/Codimer Concentrate	68478-10-4	Naphtha, petroleum, light steam-cracked, debenzenized, C8-16-cycloalkadiene conc.

Note 1: The CAS numbers associated with the corresponding production streams are shown in the above table. In some cases, more than a single CAS number is used to represent a specific stream. The Olefins Industry or others may use these same CAS numbers to represent substances that may, in various degrees, be dissimilar to the category streams. CAS numbers, other than those shown in this table may be used to describe these streams in future reporting.

Descriptions of the 9 streams associated with the Resin Oils and Cyclodiene Concentrates Category are presented below:

(1) Dicyclopentadiene (DCPD), High purity: The Olefins Industry produces this high purity DCPD stream by distillation and/or thermal processing of the DCPD Concentrate stream. DCPD content of the stream is reported at 94% to 99.5%. The main impurities remaining in the stream are codimers and trimers of cyclopentadiene.

(2) Dicyclopentadiene (DCPD) Concentrate: DCPD Concentrate is produced from the Pyrolysis C5 Fraction by a combination of distillation and heat soak (dimerization) unit operations. DCPD content of the stream is typically 75% with the balance predominantly codimers of cyclopentadiene with other C5 monomers. The stream typically contains relatively low levels of low boiling hydrocarbons (C5-C8).

(3) Methylcyclopentadiene Dimer (MCPD Dimer): MCPD Dimer is obtained by "heat soaking" the C5 to C6 fraction (debutanizer bottoms) of pyrolysis gasoline obtained from the ethylene pyrolysis process, followed by removal via distillation of unreacted, undimerized C5 and C6 molecules, followed by a thermal cracking/distillation/dimerization sequence that isolates the MCPD Dimer and other streams.

(4) Dicyclopentadiene (DCPD) Purge Stream: MCPD Dimer and DCPD/Codimer Concentrate are obtained by "heat soaking" the C5 to C6 fraction (debutanizer bottoms) of pyrolysis gasoline obtained from the ethylene pyrolysis process, followed by removal via distillation of unreacted, undimerized C5 and C6 molecules, followed by a thermal cracking/distillation/dimerization sequence that isolates these two streams. The DCPD Purge stream is a bottoms stream from this separation sequence.

(5) DCPD/Codimer Concentrate: This stream is obtained by "heat soaking" the C5 to C6 fraction (debutanizer bottoms) of pyrolysis gasoline obtained from the ethylene pyrolysis process, followed by removal via distillation of unreacted, undimerized C5 and C6 molecules, followed by a thermal cracking/distillation/dimerization sequence that isolates the DCPD/Codimer and other streams.

(6) DCPD Stream: This stream is produced as the bottoms from a distillation tower that is charged with a DCPD-containing stream (or with a DCPD Concentrate intermediate processing stream) together with the heavy ends and raffinate from an isoprene extractive distillation unit. This stream is reported to contain about 50% DCPD, with the balance being largely C5s, both saturates and unsaturates. There is existing toxicological information for the C5 olefins and paraffins to be included in an assessment of C5 mixed streams in the C5 Non-Cyclic Category Category that is also sponsored by the Olefins Panel (A complete list of test categories sponsored by the Olefins Panel is provided in Appendix 6).

(7) High DCPD Resin Oils: This stream is the C8-C10 fraction obtained by distillation from pyrolysis gasoline. The stream consists predominately of the C8-C10 aromatics produced in the ethylene process, plus DCPD and codimers of cyclopentadiene with other reactive monomers. DCPD and the codimers are formed in the process equipment during and incidental to upstream processing and storage. This stream typically contains about 55%

DCPD, and significant levels of vinyl aromatics and codimers of cyclopentadiene with other monomers such as isoprene, pentadiene and methylcyclopentadiene. The highest boiling component in the stream is normally naphthalene and it is present usually at less than about 0.5%.

(8) Low DCPD Resin Oils: Similar to the High DCPD Resin Oil stream, this stream is produced as a C8 to C10 distillate of a pyrolysis gasoline stream. Like the High DCPD Resin Oil, the stream contains C8-C10 aromatics produced in the ethylene process. This stream differs from the High DCPD Resin Oil in that it contains very low levels of DCPD. That difference occurs because the pyrolysis gasoline stream used to produce this stream is separated from the C5 and lighter hydrocarbons at the cracking furnace quench stream in the Ethylene process. This process arrangement is typical of an ethylene unit that used liquids as a cracking feedstock. As a consequence of the processing difference, dimers or codimers C5 and lighter hydrocarbons are not present at significant levels in this C8-C10 distillate. The stream consist of components that are similar to those found in the high DCPD stream (vinyl aromatics) with the exception that DCPD and the codimers are present only at very low level (typically <1% DCPD).

(9) Resin Former [Feedstock]: This stream is produced by the processing of resin oil streams from various ethylene units, and represents only about 1.5% of the category production. Resin Former is most similar to the Low DCPD stream, with typical DCPD content reported as about 6.7%.

The DCPD concentrate and DCPD/Codimers concentrate streams represent approximately 40% of the total category production by industry (excluding the volume of High Purity DCPD). Resin oil streams represent the majority of the category stream production by ethylene producers (56% of stream production as a percent of total category production and excluding High Purity DCPD).

DCPD is the major hydrocarbon component of the majority of the olefin process streams. DCPD is also representative of the chemistry of many of the components found in the Resin Oils and Cyclodiene Dimer Concentrates streams. DCPD is an OECD (Organization for Economic Cooperation and Development) SIDS (Screening Information Data Sets) chemical with an established screening data set and hazard profile for human health and environmental effects (OECD, 1998), and has been reviewed by the European Centre for Ecotoxicology and Toxicology of Chemicals (ECETOC, 1991). One characteristic of the streams in this category is the presence of dimers or codimers. Dimers are comprised of 2 units of the same molecule. In the case of DCPD, the dimer is comprised of 2 molecules of the monomer cyclopentadiene. The dimer of methylcyclopentadiene (MCPD) is the other dimer found in the category streams at significant concentrations. In addition, cyclopentadiene and MCPD molecules combine with each other or individually with other reactive molecules such as butadiene, isoprene, piperylenes and vinyl aromatics to form codimers.

There are a number of components found in the category streams, however, the majority of the streams are similar in terms of their carbon number range, the hydrocarbon class and the dimer/codimer versus monomer content. DCPD is a C10, dimer, aliphatic hydrocarbon and the majority of the category streams are comprised of predominately C8 to C12, dimers and/ or codimers, aliphatic hydrocarbon components. The DCPD content of these streams ranges from

1% to 94+%. Some of the processes used in stream manufacture, however, do yield variations in the hydrocarbon attributes with a few streams differentiated with higher content of C5 to C7, monomer, or aromatic content.

1.2 Purity/Impurities/Additives

CAS numbers in this category are used to represent extremely complex mixture of hydrocarbons from C4-C12, predominantly in the C8 – C12 carbon range. Typically there are no impurities in the streams in this category. The typical compositions of streams in this category are listed in Appendix 2.

1.3 Physico-Chemical Properties

Properties for the Resin Oils and Cyclodiene Dimer Concentrates category have been estimated from calculated and measured values for representative constituents and several streams of the category. Substances in this category consist of complex hydrocarbon products with a carbon number distribution that is predominantly C8-C12. Calculated data has been derived using subroutines of the EPIWIN© version 3.04 computer model (EPIWIN, 1999) described in the USEPA document "The Use of Structure-Activity Relations (SAR) in the High Production Volume Chemical Challenge Program (USEPA, 1999a). Robust summaries for Physico-Chemical property studies are provided as Attachment 1a.

Table 2. Summary of Calculated Physico-Chemical Properties for Selected Chemicals and Representative Streams in the Resin Oils and Cyclodiene Dimer Concentrates Category

Substance Constituent	Melting Point (°C)	Boiling Point (°C@760mm Hg)	Vapor Pressure (hPa@ 25°C)	Log K_{ow} (@ 25^0C)	Water Solubility (mg/L@25^0C)
Vinyl toluene	-60.33	120.42	20.53	2.48	935.0
Indene	24.36	212.89	0.25	2.88	372.1
Dicyclopenta-diene (DCPD)	-16.78	176.78	2.2	3.16	51.9
Methylindene	35.06	231.75	0.07	3.42	112.7
Methylcyclo-pentadiene Dimer (MCPD Dimer)	3.13	225.19	0.20	5.27	0.62

Calculated values determined by EPIWIN [EPIWIN 1999. Estimation Program Interface for Windows, version 3.04. Syracuse Research Corporation, Syracuse, NY, USA.].

Table 3. Summary of Measured Physico-Chemical Properties for Selected Chemicals and Representative Streams in the Resin Oils and Cyclodiene Dimer Concentrates Category

Substance Constituent	Melting Point (°C)	Boiling Point (°C@760mm Hg)	Vapor Pressure (hPa@ 25°C)	Log K_{ow} (@ 25^0C)	Water Solubility (mg/L@25^0C)
Vinyl toluene	na	na	na	na	na
Indene	na	na	na	na	na
Dicyclopenta-diene (DCPD)	32.0	170.0	3.05	na	na
Methylindene	na	na	na	na	na
Methylcyclo-pentadiene Dimer (MCPD Dimer)	na	191.0	19.0	5.5-5.7	na
DCPD/Codimer Conc.	na	150-197	0.80	3.2-5.9	na
Low DCPD Resin Oil	na	174-193	41.0	3.1-4.7	na

na = not available
Measured values from the experimental database in EPIWIN [EPIWIN, 1999. Estimation Program Interface for Windows, version 3.04. Syracuse Research Corporation, Syracuse, NY, USA.].

These ranges as described below can be used to define the 5 physico-chemical endpoints of substances in this category.

1.3.1 Melting Point (Range)

The calculated melting points (by subroutine MPBPWIN, version 1.40) for representative compounds and 2 streams in the category vary from –60.33 to 35.06^0C. The only measured melting point available was 32°C for DCPD, a value significantly higher than the calculated value of $–16.78^0$C. Although this range does not define the actual melting points of the category streams, it offers an indication of a range that might be expected to encompass the melting points of these complex streams with variable compositions. Melting points outside these ranges may be possible for some category streams.

1.3.2 Boiling Point (Range)

The calculated boiling points (by subroutine MPBPWIN, version 1.40) for representative compounds and 2 streams in this category vary from 120.42 to 231.75°C @ 760 mm Hg. The measured boiling points for representative streams in this category vary from 150.0 to 197°C @ 760 mm Hg, which are within the calculated ranges. Although this range does not define the actual boiling points of the category streams, it offers an indication of a range that might be expected to encompass the boiling points of these complex streams with variable compositions. Boiling points outside these ranges may be possible for some category streams.

1.3.3 Vapor Pressure (Range)

The calculated vapor pressures (by subroutine MPBPWIN, version 1.40) for representative compounds and 2 streams in this category vary from 0.07 to 20.53 hPa @ 25°C; the highest value was vinyl toluene. The measured vapor pressures of streams in this category vary from 0.80 to 41.0 hPa @ 25°C, which extended beyond the calculated range. Although this range does not define the actual vapor pressures of the category streams, it offers an indication of a range that might be expected to encompass the vapor pressures of these complex streams with variable compositions. Vapor pressure outside these ranges may be possible for some category streams.

1.3.4 Partition Coefficient: Log K_{ow} (Range)

The calculated log K_{ow} (by subroutine KOWWIN, version 1.65) for some representative compounds and 2 streams in this category vary from 2.48 to 5.27 @ 25°C. The measured log K_{ow} for streams in this category vary from 3.1 to 5.9 @ 25°C, and are similar to the calculated values. Although this range does not define the actual log K_{ow} of the category streams, it offers an indication of a range that might be expected to encompass the log K_{ow} of these complex streams with variable compositions. Log K_{ow} values outside these ranges may be possible for some category streams.

1.3.5 Water Solubility (Range)

The calculated water solubility (by subroutine WSKOWWIN, version 1.36) for some representative compounds and 2 streams in this category vary from 0.62 to 935.0mg/L @ 25°C. No measured water solubility data were available. Although this range does not define the actual water solubility of the category streams, it offers an indication of a range that might be expected to encompass the water solubility of these complex streams with variable compositions. Water solubilities outside these ranges may be possible for some category streams.

1.4 Category Justification

The Resin Oils and Cyclodiene Dimer Concentrates Category is comprised of 9 related complex mixtures consisting of C4-C12 aliphatic and aromatic hydrocarbons in different proportions. The aliphatics are primarily dimers and unreacted monomers, and the aromatics are primarily vinyl benzene and related congeners. The primary dimers present are of mono- and dicyclopentadiene. Since the 9 process streams contain hydrocarbons derived from the ethylene process unit it can be surmised that toxicities of the streams would be similar, however, the different ratios of aliphatics to aromatics suggest there may be toxicological differences. For health effects testing, the Resin Oils and Cycodiene Dimer Concentrates Category can be grouped into 3 subcategories which are representative of the 9 process streams based on the relative proportions of aliphatic (cycloalkene, DCPD) and aromatic compounds in the complex mixtures (Table 4).

- Subcategory 1: 98+-99+% aliphatics; <1 to <2% aromatics: The cyclodiene dimer concentrate streams contain high levels of dimers/codimers and lower levels of alkane monomers. These streams are DCPD, High purity, DCPD Concentrate, MCPD Dimer, DCPD Purge Stream, DCPD/Codimer concentrate and DCPD stream. In one processing arrangement for isolating these concentrates, a C5 fraction is distilled from pyrolysis gasoline, dimerized and then redistilled to produce a DCPD concentrate. In alternate processing, a high-boiling fraction of pyrolysis gasoline is heat soaked and then distilled to isolate 2 other cyclodiene dimer streams, DCPD/Codimers Concentrate, and the MCPD Dimer stream. In the DCPD concentrate and DCPD/Codimer concentrate streams, DCPD is in a mixture with codimers of comparable molecular weight.

- Subcategory 2: 35-70% aliphatics, 30-65% aromatics: Two streams contain dimers and codimers as well as substantial levels of aromatic monomers. These streams are High DCPD Resin Oil and Resin Former Feedstock.

- Subcategory 3: <5% aliphatics, 95+% aromatics: One stream is comprised almost entirely of aromatic monomers – Low DCPD Resin Oil.

The approach of the Resin Oils and Cyclodiene Dimer Concentrates Streams health effects assessment was to evaluate the toxicity of subcategories 1 and 3 to determine if the extremes of the ranges yield signficantly different toxicological effects, and then as appropriate, project the likely toxic effects of subcategory 2. In addition to review of available data on DCPD and other streams, samples selected for testing from Subcategory 1 were DCPD/Codimer Concentrate [mid-range content of DCPD `40% and comparable molecular weight dimers/codimers], and MCPD Dimer, a high purity C12 cycloalkene dimer. Low DCPD Resin Oil, [<1% DCPD and high C8-C12 aromatic content] was tested from Subcategory 3. All samples were derived from production facilities and were not prepared mixtures.

Table 4. Resin Oils and Cyclodiene Dimer Concentrates Category Streams Analyses

Stream Analysis (see note 1)

INDUSTRY PROCESS STREAM (see Note 3)	STREAM TYPE (see Note 5)	DCPD content	MCPD Dimer	CARBON # RANGE C8-C12	C4 - C7	DIMER/CODIMER VS MONOMER Dimer/ codimer	Monomers	HYDROCARBON CLASS Aliphatic (see note 2)	Aromatic
Subcategory 1									
DCPD High Purity	Cyclodiene Dimer Concentrate	**94+**	**<1**	**98+**	**< 2**	**98+**	**< 2**	**99+**	**< 1**
DCPD Concentrate	Cyclodiene Dimer Concentrate	80	<1	90+	< 10	90+	< 10	98+	< 2
MCPD Dimer	**Cyclodiene Dimer Concentrate**	**< 1**	**90**	**99+**	**< 1**	**90+**	**< 10**	**99+**	**< 1**
DCPD Purge Stream	Cyclodiene Dimer Concentrate	18	18	99+	< 1	90	10	99+	<1
DCPD / Codimer Concentrate	**Cyclodiene Dimer Concentrate**	**41**	**10**	**99+**	**< 1**	**99+**	**< 1**	**99+**	**< 1**
DCPD Stream	Cyclodiene Dimer Concentrate	note 4	<1	60	40	60	40	99+	<1
Subcategory 2									
High DCPD Resin Oil	Resin Oil	55	1	98+	< 2	70	30	70	30
Resin Former Feedstock	Resin Oil	7	5	98+	<2	**25**	**75**	35	65
Subcategory 3									
Low DCPD Resin Oil	**Resin Oil**	**<1**	**<1**	**98+**	**<2**	**<1**	**>99**	**< 5**	**95+**

Note 1: Analysis shown above is an approximate of the range for select compositional attributes of the industry streams
Note 2: Aliphatics includes alkanes, alkenes and their cyclic analogs
Note 3: Streams indicated in bold above have been tested
Note 4: DCPD was reported in combination with Codimers of CPD and other C5s. A value of 55-60% was reported.
Note 5: Streams for which new data was developed for this test plan are indicated in bold.

2 EXPOSURE AND USE

The Category & HPV Stream Production: The Resin Oils & Cyclodiene Dimer Concentrates Category of the American Chemistry Council Olefins Panel's HPV program includes 8 commercial product streams and dicyclopentadiene, high purity produced by the Olefins Industry. The category streams are complex hydrocarbon mixtures with variable compositions, and with the exception of a single stream that contains C5s, have a carbon range that is predominantly C8-C12. There are two general types of Resin Oils – those that contain significant concentrations dicyclopentadiene (DCPD) and those with little or no DCPD content. The balance of the composition of the resin oils is primarily vinyl-aromatics. The Cyclodiene Dimer Concentrates are non-aromatic hydrocarbon concentrates of DCPD with codimers of other C4 to C6 hydrocarbons, or in a single case a 90% concentrate of methyclcyclopentadiene dimer (MCPD Dimer). The category streams are derived from pyrolysis gasoline produced by the ethylene manufacturing process. The streams are isolated intermediates that are transferred under controlled conditions to a limited number of second parties that use the streams in a controlled way as an intermediate with well-known technology. In limited cases, category streams may be blended with other streams to produce fuel oil or other fuels, or may be recycled to the process for further chemical processing.

Distribution of the 885 million pounds/year[1] of category production among the category streams is shown in Figure 1. As shown in the figure, the Resin Oils account for 56% of the category and the Cyclodiene Dimer Concentrates make up the balance.

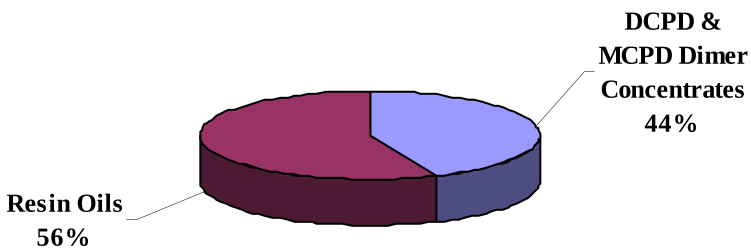
Other industrial processes also produce some of the hydrocarbon compounds that make up the complex streams in this category. Potential exposures for these individual components from other manufacturing processes or from natural sources are considered to be out of scope for this assessment. This assessment is limited to potential exposures to the streams in the category. Some data is presented for specific components, which is intended to help clarify the potential for exposure to the category streams.

This screening level exposure assessment is based on information received from 6 of the 8 original sponsors of the Category and upon other available information. The producers of the category streams that provided information for this report indicated either that their customer's unloading, storage and use of these streams takes place in closed systems, or that specific information on the customer's handling of the streams was not available. Other than that information, this assessment does not include information on exposure potentials that may occur during use of the category streams, because that additional information was not available.

There are 10 CAS numbers that are used by the Olefins Industry to represent the 9 category streams (Table 5). This assessment addresses the use of the CAS numbers for the Resin Oils and Cyclodiene Dimer Concentrates Category streams. Some of the CAS numbers in this category may be used by the Olefins Industry or others to represent other substances that are not included in the Resin Oils and Cyclodiene Dimer Concentrates Category, and may be included in other HPV categories.

[1] 885 Million pounds per year is the approximate total annual commercial production of category streams reported by the sponsors of the category and based on their 1998 TSCA IUR.

Figure 1
Resin Oils & Cyclodiene Dimer Concentrates
Category Production (1998 Data)[a]



a- Does not include volume of DCPD High Purity

2.1 Table 5. Resin Oils & Cyclodiene Dimer Concentrate Category Streams

DCPD & MCPD Dimer Concentrates	Resin Oils
DCPD Concentrate	High DCPD Resin Oil
DCPD/Codimer Concentrate	Low DCPD Resin Oil
DCPD Stream	Resin Former
DCPD Purge	
MCPD Dimer Concentrate	
DCPD High purity	

DCPD: Dicyclopentadiene MCPD: Methylcyclopentadiene

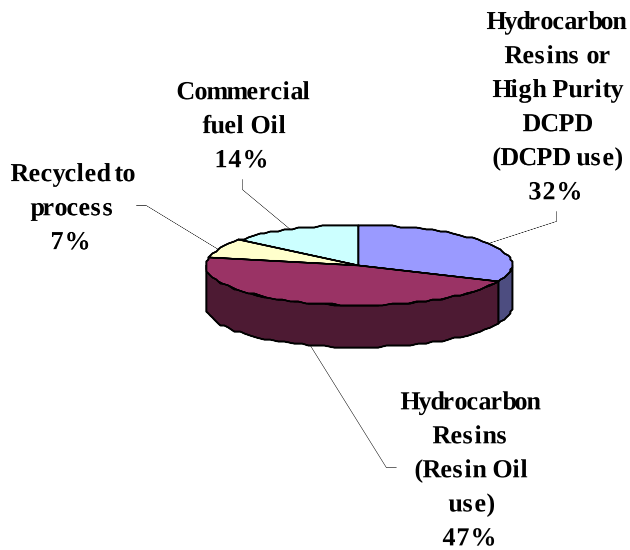
Storage and Transportation of Category Streams: When shipped between industrial sites, the category streams are transported in bulk in closed systems by pipeline, barge, tank car or tank truck. The streams are typically inventoried in bulk storage tanks, either floating roof or fixed roof with vents routed to a control device in order to reduce emissions.

Use: Uses of the category streams are shown in Figure 2. No consumer uses were reported or expected for the category streams [use data on 3 streams was not available]. The primary uses for the category streams are as reactive intermediates in the production of resins. The remaining known uses are in fuels and as intermediates for further chemical processing.

Resin Oils are used to produce hydrocarbon resins. These resins have various applications such as in inks, adhesives, caulks, paints, coatings, concrete cures and rubber processing aids. DCPD concentrates are also used to produce hydrocarbon resins with uses that include in inks, adhesives and floor tile. The industry's customers sometimes process DCPD concentrates to produced higher purity DCPD. Polyester grade DCPD (80-90% DCPD) is used to produce Unsaturated Polyester Resins that are used in the manufacture of fiberglass boats, shower stalls and tubs, vanity marble, automobile parts and in electrical applications. High purity DCPD is used as an intermediate in the production of ethylene propylene diene monomer, or EPDM (used for example, to make water fitting for washing machines and dishwashers, hydraulic brake systems, and roofing membrane), fragrances, insecticides, specialty lubricants, electrical insulating coatings, poly-DCPD (used for example to make heavy-vehicle exterior components), specialty fertilizer, specialty organic compounds and ethylidene norbornene (an intermediate).

Figure 2 does not include use data for the following 3 category streams – Methycyclopentadiene Dimer, DCPD/Codimer Concentrate and the DCPD Purge stream. Use information was not available from the producer of these streams at the time this report was prepared.

Figure 2
Available Use Information for the Resin Oils and Cyclodiene Dimer Concentrates Category Streams (2001 data) [2]



Route of Potential Exposure: The category streams are liquids at ambient conditions. Contact by inhalation of vapors generated by evaporation of the liquid stream - for example in event of a spill, or accidental dermal contact with the liquid - are the most likely routes of exposure. The streams or components in the streams are slightly soluble in water and therefore groundwater contamination is possible in the event of spills or leaks from production, transportation or storage equipment.

Sources of Potential Exposure: Exposure to the category streams for workers in the Olefins Industry process units where the category streams are isolated is expected to be low because that equipment and those processes are closed systems. Emissions from storage and loading equipment are typically controlled by using floating roof storage tanks or by routing vents from fixed roof storage tanks and loading equipment to control or recovery systems, or back to process. For the industrial workers at these facilities, the most likely exposure potential occurs through inhalation of low-level concentrations in air of vapors that escape from the closed process, such as fugitive emissions from valve packing and from pump seals. Other potential for exposure may result during operations such as sampling, loading of bulk transportation vessels (tank cars, tanks trucks and barges), from emissions at floating roof storage tanks, or during

[2] The percentage uses of the category streams are based on data received from 6 of the original 8 category sponsors. Uses of 3 of the category streams is not included in Figure 2, because use information was not available from the sponsor of the streams at the time this report was written.

infrequent opening of equipment for maintenance, and from emissions from control devices, such as flares.

The above-described sources of emissions of the category streams may present a potential for exposure to the public and to the environment adjacent to the industrial facilities that use or produce the category streams.

DCPD is a component found in significant concentrations in 6 of the 8 category streams. "Occupational exposure to dicyclopentadiene may occur by inhalation or dermal contact during its production and use as a chemical intermediate. Probable routes of exposure to the general population may be limited to inhalation for those near its sites of production or use, or by the ingestion of contaminated water."[3]

Controls that Limit Exposure: The American Conference of Governmental Industrial Hygienists (ACGIH) adopted an 8-hour time-weighted average threshold limit value (TLV) for DCPD of 5 ppm.[4] DCPD is a component found in significant concentrations in 6of the 8 category streams.

Four of the original 8 sponsors of the category streams reported that they have programs that assess exposure to the category streams, including specific measurements of some of the stream components. Industrial hygiene programs for a specific production site are typically unique to the site and address the specific chemical exposure issues. Some of the components typically present in the category streams that have OSHA PELs or ACGIH TLVs are shown in Table 6.

Table 6. Components typically present in some streams of Resin Oils and Cyclodiene Dimer Concentrates Category that have OSHA PELs or ACGIH TLVs

Component	OSHA PEL	ACGIH TLV	Component	OSHA PEL	ACGIH TLV	Component	OSHA PEL	ACGIH TLV
Benzene[a]	1	0.5	Ethylbenzene	100	100	Toluene	200	50
Cumene	50	50	Indene	-	10	Vinyltoluene	100	50
CPD[b]	75	75	Naphthalene	10	10	Xylenes Isomers	100	100
DCPD[c]	-	5	Styrene	100	20			

[a] Benzene is a component found in some of the category streams at low concentrations

[b] CPD: Cyclopentadiene [c] DCPD: Dicyclopentadiene

Among other reasons, the release of the category streams from process, storage and transportation equipment at industrial facilities is avoided because the streams are flammable liquids.

The category streams are mixtures of volatile organic compounds (VOC) and are therefore subject to USEPA and state environmental regulations that limit VOC emissions. The USEPA New Source Performance Standards (NSPS) of 40 CFR Part 60 may be applicable and limit emissions of VOC at new or modified Olefins process units where the streams in the category are produced and used. Subpart VV of NSPS limits emission from equipment leaks, subpart NNN

[3] http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?HSDB

[4] 2003 TLVs and BEIs, Threshold Limit Values for Chemical Substances and Biological Exposures Indices, ACGIH, Cincinnati, OH 45240-1634.

limits emissions from distillation operations, and subpart Kb limits emissions from VOC storage tanks. These emissions control requirements effectively limit exposure potentials of the category streams for both workers at the facilities and the neighboring public and for the environment.

Ambient Concentration Data: Ambient air concentration data for the complex category streams was not available. DCPD is a component found in significant concentrations in 6 of the 8 category streams. "Dicyclopentadiene has been found in 2 of 63 industrial effluent samples obtained from a wide range of chemical manufacturers from 1976-1978 in areas across the USA at a concentration of <10 ug/Lm"[3]

Estimates of Potentially Exposed Workers: DCPD is a component found in significant concentrations in 6 of the 8 category streams. "NIOSH (NIOHS Survey 1972-1974) has statistically estimated that 747 workers are exposed to dicyclopentadiene in the USA."[3]

Category Emissions: Emissions quantities of the mixed streams are not available. DCPD is a component found in significant concentrations in 6 of the 8 category streams. Beginning in 1995, industrial emissions of DCPD are reported to the EPA and made available to the public in the Toxics Release Inventory (TRI).[5] This inventory was established under the Emergency Planning and Community Right-to-Know Act of 1986 (EPCRA) and expanded by the Pollution Prevention Act of 1990.

The TRI data indicate that reported emissions and waste of DCPD were at a level of about 350,000 lbs/yr from 1995 through 1997. The reported values increased to nearly 1,500,000 lbs/yr in 1997. The 2002 reported value of 241,000 lbs/yr represents a 32% decrease from 1995 and 76% decrease from 1998. However the relevance of individual component emissions values with regard to the category streams is uncertain, because the category streams likely account for only a portion of the total emissions of DCPD.

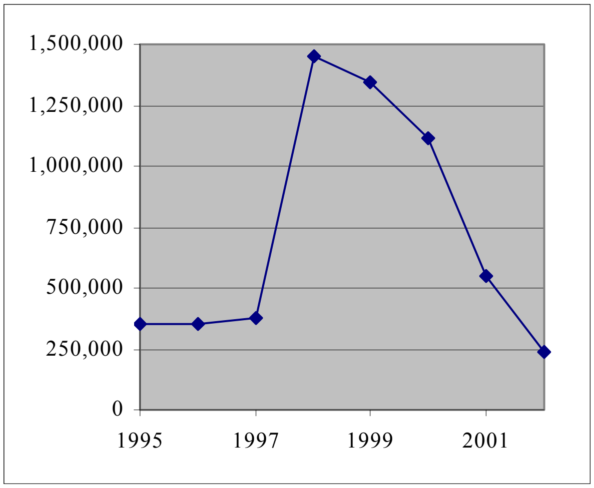


Figure 3

TRI DCPD Total Disposal & Emissions (lbs/year) for All Industries 1988 - 2002

SUMMARY OF EXPOSURE ASSESSMENT

The HPV Resin Oils & Cyclodiene Dimer Concentrates Category is made up of Dicyclopentadiene, High Purity and 8 commercial streams from the Olefins Industry that are

[5] EPA website for TRI: http://www.epa.gov/tri/

cyclodiene dimer concentrates and/or C8-C10 vinyl aromatics. One of the category streams also contains C5 hydrocarbons. Ten CAS numbers are used to represent these streams. The category streams are complex mixtures of variable composition that are isolated from Pyrolysis Gasoline produced by the ethylene manufacturing process. Resin Oils account for 56% of the category volume of 885 million pounds/year and the Cyclodiene Dimer Concentrates make up the balance.

This report does not include an exposure assessment for Methylcyclopentadiene Dimer, DCPD/Codimer Concentrate and for the DCPD Purge Stream because production, handling and use information for those streams was not available at the time the report was written.

This screening level exposure assessment is based on information received from six of the eight original sponsors of the Category and upon other available information. The producers of the category streams that provided information for this report indicated either that their customers' unloading, storage and use of these streams take place in closed systems, or that specific information on the customers' handling of the streams was not available. Other than that information, additional information on exposure potentials that may occur during use of the category streams was not available.

The category streams are typically transported to other industrial facilities in bulk by pipeline, barge, tank car or tank truck. The primary use for the Resin Oil streams and DCPD concentrates is as reactive intermediates in the production of resins, such as hydrocarbon resins. DPCD concentrates are also processed to higher purity DCPD streams for other resin production and intermediate uses. The category streams may also be used in fuel blends. There are no expected consumer uses of the category streams.

The category streams are liquids at ambient conditions. Inhalation or accidental dermal contact are therefore the most likely routes of potential exposure. The streams or components in the streams are slightly soluble in water so groundwater contamination is possible from spills or leaks.

Occupational exposure to the category streams is expected to be low because the equipment and processes where the streams are managed are closed systems. For the industrial workers at these facilities, the most likely exposure potential occurs through inhalation of low-level concentrations in air of vapors that escape from the closed process, such as fugitive emissions from valve packing and from pump seals, or from other sources of emissions from the closed processes. The ACGIH TLV for DCPD of 5 ppm limits exposure to the category streams that contain significant concentrations of DCPD (6 of the 8 category streams). Occupational exposure limits of other components that make up the category streams also limit exposures.

Environmental exposure is expected to be low since the category streams are used primarily in closed systems as chemical intermediates. Emissions from industrial processes, such as fugitive emissions from valve packing and from pump seals may present a potential for exposure to the public and to the environment adjacent to the industrial facilities that use or produce the category streams.

The category streams are subject to USEPA regulations that limit emissions of volatile organic compounds and hazardous air pollutants, and to additional state or local environmental requirements. These emissions limits effectively limit exposures to the category streams for both workers at the facilities and to the neighboring public and environment.

The TRI data indicate that 2002 emissions and waste of DCPD have decreased 32% from reported value in 1995 the first year data was reported.

3. ENVIRONMENTAL FATE

3.1 Photodegradation

3.1.1 Direct photodegradation:

The absorption of light in the ultraviolet (UV) visible range (110 to 750nm) can induce electronic excitation of an organic molecule. The stratospheric ozone layer allows only light in wavelengths in the 290 to 750nm range to reach earth's surface with the potential to result in photochemical transformation in the environment. To estimate photochemical degradation, it is assumed that degradation will occur in proportion to the amount of light wavelengths greater than 290nm absorbed by the molecule (Zepp and Cline, 1977). Saturated hydrocarbons do not absorb appreciable light energy above 200nm. Olefins with 1 double bond or 2 conjugated double bonds, which constitute the majority of chemicals in the Resin Oils and Cyclodiene Dimer Concentrates Category, do not absorb appreciable light energy above 290nm. The absorption of UV light to cause cis-trans isomerism about the double bond of an olefin occurs only if it is in conjunction with an aromatic ring (Harris, 1982a). Examples of absorbance maxima (λ max) and associated molar absorptivities (ϵ) for representative hydrocarbons are shown below.

Table 7. Characteristic Absorbance Maxima (λmax) and Associated Molar Absorptivities (ε) for Representative Hydrocarbons of the Resin Oils and Cyclodiene Dimer Concentrates Category

Hydrocarbon	λ below 290 nm		λ above 290 nm	
	λ_{max}	ε	λ_{max}	ε
Ethylene	193	10,000	--	--
Benzene	255	215	--	--
Styrene	244 282	12,000 450	--	--
Naphthalene	221 270	100,000 5,000	311	250

Only naphthalene demonstrated some photochemical degradation at wavelengths above 290nm.

Products in the Resin Oils and Cyclodiene Dimer Concentrates Category do not contain component molecules that will undergo direct photolysis, with the exception of naphthalene. This process will not contribute a measurable degradative removal of chemical components in this category from the environment.

3.1.2 Indirect photodegradation (Atmospheric Oxidation):

Atmospheric oxidation as a result of hydroxyl radical attack is not direct photochemical degradation but an indirect degradation process. Hydrocarbons such as those in the Resin Oils and Cyclodiene Dimer Concentrates Category have the potential to volatilize to air where they can react with hydroxyl radicals (OH-). The rate at which an organic compound reacts with OH- radicals is a direct measure of its atmospheric persistence. The AOPWIN version 1.89 computer program (subroutine of EPIWIN 3.04) was used to estimate the rate constants for OH- radical reactions of representative organic constituents of the products in the Resin Oils and Cyclodiene Dimer Concentrates Category, which were then used to calculate atmospheric half-lives for these constituents (Table 8):

Table 8. Hydroxy Radical Photodegradation Half-lives of Representative Hydrocarbons of the Resin Oils and Cyclodiene Dimer Concentrates Category

Chemical	Calculated* half-life (hrs)	OH- Rate Constant (cm^3/molecule-sec)
Vinyl toluene	44.5	2.9 E^{-12}
Indene	53.0	2.4 E^{-12}
Dicyclopentadiene	1.1	119.2 E^{-12}
Methyl indene	50.2	2.6 E^{-12}
Methylcyclopentadiene Dimer	0.7	173.1 E^{-12}

* Atmospheric half-life values are based on a 12-hr day.

Based on these calculated values, for representative stream constituents, products in the Resin Oils and Cyclodiene Dimer Concentrates Category can have an atmospheric half-life range of 0.7 to 53 hours, indicating that atmospheric oxidation can be a significant route of degradation for products in this category.

3.2 Stability in Water

Hydrolysis of an organic molecule occurs when a molecule (R-X) reacts with water (H_2O) to form a new carbon-oxygen bond after the carbon-X bond is cleaved (Gould, 1959; Harris, 1982b). Mechanistically, this reaction is referred to as a nucleophilic substitution reaction, where X is the leaving group being replaced by the incoming nucleophilic oxygen from the water molecule. The leaving group, X, must be a molecule other than carbon because for hydrolysis to occur, the R-X bond cannot be a carbon-carbon bond.

The carbon atom lacks sufficient electronegativity to be a good leaving group and carbon-carbon bonds are too stable (high bond energy) to be cleaved by nucleophilic substitution. Under strongly acidic conditions the carbon-carbon double bond found in alkenes will react with water by an addition reaction mechanism (Gould, 1959). The reaction product is an alcohol. This reaction is not considered to be hydrolysis because the carbon-carbon linkage is not cleaved and because the reaction is freely reversible (Harris, 1982b). This reaction differs from other reactions with water such as hydration of carbonyls that can lead to the formation of an alcohol beginning with the transfer of a proton from the water to an alkene. However, water by itself is too weak an acid to transfer a proton in the absence of a strong acid, which could affect such an acid catalyzed electrophilic addition.

Chemicals that have a potential to hydrolyze include alkyl halides, amides, carbamates, carboxylic acid esters and lactones, epoxides, phosphate esters, and sulfonic acid esters (Neely, 1985). The chemicals in the Resin Oils and Cyclodiene Dimer Concentrates Category are primarily aromatics and olefins (alkenes) that contain at least 1 double bond. However, streams in this category can contain amounts of saturated hydrocarbons (alkanes). These groups of chemicals contain only carbon and hydrogen. As such, their molecular structures are not subject to the hydrolytic mechanisms described above (Harris, 1982b) under conditions typically found within the environment. Therefore, this fate process will not contribute to the degradative loss of chemical constituents in this category from the environment.

3.3 Distribution in the Environment

Substances in the Resin Oils and Cyclodiene Dimer Concentrates Category are calculated to partition primarily into air or to air, water and soil with a relatively small proportion in sediment (Table 9). The 5 chemicals selected to represent the environmental distribution of category members range in carbon number between C8 to C12 and are predominant across the streams in this category. Physical property data (Table 2) used in the model are from the EPIWIN (1999) database.

The EQC level 1 fugacity model (Mackay *et al*., 1996) recommended by US EPA (1999b) was used to determine partitioning of representative chemical constituents into different environmental compartments under steady state conditions, in order to estimate the partitioning behavior for the category substances.

Table 9. Environmental Distribution as Calculated by EQC Level I Fugacity Model for Representative Hydrocarbons of the Resin Oils and Cyclodiene Dimer Concentrates Category

Chemical	**Percent Distribution: Calculated[a] [Measured][b]**			
	Air	Water	Soil	Sediment
Vinyl toluene	96.94 [na]	2.40 [na]	0.64 [na]	0.02 [na]
Indene	47.61 [na]	31.05 [na]	20.86 [na]	0.46 [na]
Methyl indene	32.02 [na]	20.10 [na]	46.81 [na]	1.04 [na]
Dicyclopentadiene (DCPD)	98.00 [98.00]	0.87 [0.87]	1.11[1.11]	0.02 [0.02]
Methylcyclopentadiene Dimer (MCPD Dimer)	85.98 [na]	0.09 [na]	13.62 [na]	0.03 [na]

a- Values determined using calculated input data from EPIWIN program; na = not available
b- Values determined using input data from the EPIWIN program experimental database.

Vinyl toluene, DCPD and MCPD Dimer are most representative of the environmental distribution of the category, partitioning primarily into air at 85 to 98% with some distribution into soil and water. Indene and methyl indene partition more broadly, with 32 to 48% in air, 20 to 31% in water and 20 to 47% in soil. Partitioning into sediment was negligible for all compounds.

3.4 Biodegradation

There are sufficient data to characterize the potential biodegradability of process streams in this category (Appendix 4) for purposes of the HPV program. The representative streams of this category tested for biodegradability contain varying concentrations of DCPD from moderate to <1.0%. Although data from chemicals contained in products from this category demonstrated the potential to biodegrade from 29 to 100% within 28 days, testing of actual streams indicated limited biodegradability. Whether concentration of DCPD was moderate (DCPD/Codimer Concentrate) or low (Low DCPD Resin oil) or a separate dimer (MCPD Dimer) was tested, the extent of biodegradation demonstrated using an unacclimated inoculum was negligible or low. However, Low DCPD Resin Oil exhibited 44% biodegradation after 56 days with an acclimated inoculum, which shows that microorganisms are capable of acclimating to these streams and that higher extents of biodegradation may be achieved with competent microbial populations [Robust summaries in Attachment 1c].

The data from the majority of tests in Appendix 4 were developed using a manometric respirometry test procedure. This procedure uses continuously stirred, closed systems, which is recommended when assessing the potential biodegradability of chemically complex, poorly water soluble, and volatile materials like those in this category. Stirring is recommended when evaluating products containing several chemicals, some of which may have limited water solubility.

Results of studies employing OECD guideline 301F indicate that representative product streams of the Resin Oils and Cyclodiene Dimer Concentrates Category are not readily biodegradable over 28 days but are inherently biodegradable over time.

4. HUMAN HEALTH HAZARDS

4.1 Effects on Human Health

The 9 streams in the Resin Oils and Cyclodiene Dimer Condensates Category are commercial hydrocarbon products derived by distillation and in some cases thermal processing and further purification of the pyrolysis gasoline stream from ethylene process unit. The streams in this category are complex mixtures containing primarily C8-C12 cycloalkenes, of which dicyclopentadiene is a major chemical component, and aromatic hydrocarbons. The streams in this category are further subcategorised based on the content of aliphatic cycloalkene and aromatic compounds (see Table 4 above). Subcategory 1 contains streams with 98-99+% aliphatics and low aromatics; subcategory 2 contains streams with 35-70% aliphatics and 30-65% aromatics; and subcategory 3 contains streams of 95+% aromatic and low aliphatic content. Data are available for streams in all subcategories and additional recent testing has been performed on representative streams from subcategories 1 and 3 to evaluate toxicity of the extremes of chemical content for this category. Health effects data on representative streams are summarized in Appendix 3. Robust summaries for described studies are located in Attachment 1b.

4.1.1 Acute Toxicity

Studies in Animals

Table 10. Summary of Acute Toxicity Data for Representative Streams of the Resin Oils and Cyclodiene Dimer Concentrates Category

Product Stream	Oral LD50	Inhalation LC50	Dermal LD50
Subcategory 1			
DCPD High Purity	Rat = 0.346 – 0.82g/kg [a]	Rat M =284ppm [1.52g m^3] F = 353ppm [1.89g/m^3] Mice M = 143ppm [0.76g/m^3] F = 130 ppm [0.69g/m^3]	na
MCPD Dimer	Rat > 10g/kg	Rat > 495ppm [>3.2g/m^3] Mice > 450ppm [2.91g/m^3]	Rabbit > 3.16g/kg
Subcategory 2			
High DCPD Resin Oil	Rat = 0.96g/kg	Rat > 5.4g/m^3	Rabbit > 2g/kg
Subcategory 3			
Low DCPD Resin Oil	Rat > 2g/kg	Rat M = 1.40mg/L F = 1.90mg/L M&F >1.65mg/L	na

a- data from ECETOC, 1991
na = not available

Conclusion

For acute toxicity in the rat by inhalation, all of the LC50s were above 1g/m^3 and there did not appear to be any relationship between the LC50s and the varying compositions of the 4 articles tested. For acute toxicity by oral administration, LD50s were between approximately 0.4 to 0.8 and 10g/kg. For the 4 articles tested, toxicity was greatest for the sample (DCPD High Purity) with the highest level of DCPD.

4.1.2 Repeated Dose Toxicity

Studies in Animals

Systemic toxicity studies have been performed for representative product streams in each subcategory by various routes of exposure. Inhalation, oral gavage studies and a dermal toxicity study are described below. Four product streams were tested by the oral route in the OECD 422 Combined Repeat Dose Toxicity Study with Reproduction/Developmental Screening to fully characterize the toxicity of the category for purposes of the HPV program. For these studies, reproduction/developmental data are discussed in Section 4.1.4 below.

Subcategory 1

DCPD High Purity was tested orally by gavage according to the OECD 422 protocol at concentrations of 0, 4, 20 and 100mg/kg/day in rats (JETOC, 1998). Two of 10 high dose females died during treatment and all treated males and surviving females showed slight suppression of body weight gain and decreased feed consumption. Male rats of the high dose group demonstrated increase in liver enzymes, increased liver and kidney weight, and microscopic findings of single cell necrosis in the liver and hyaline droplets and renal tubular changes in the kidney. The kidney microscopic changes were also observed in the male rats that received 4 and 20 mg/kg DCPD. The hyaline droplet effect (HDE) with subsequent nephropathy is a hydrocarbon-induced male rat specific syndrome that is not considered relevant to human health (USEPA, 1991). Both males and females in the 100mg/kg group and males in the 20mg/kg group also exhibited increase in fatty droplets in the adrenal glands. The NOAEL doses for repeat dose toxicity for this study were considered to be 20 mg/kg/day for females and 4 mg/kg/day for males [HDE excluded]. Neurobehavioral tests were not reported.

Repeat inhalation exposure of rats for 13 weeks to 0, 1.0, 5.1 or 51ppm induced increased kidney weight, hyaline droplet effect (HDE) and nephropathy in male rats. The NOAEL for males excluding HDE was 1ppm. Females were unaffected by exposure, NOAEL = 51ppm. Similar exposure in mice produced a NOAEL = 5.1ppm for both sexes, due to 20% mortality at 51ppm but no other systemic effects among survivors.

DCPD/Codimer Concentrate was tested orally by gavage according to the OECD 422 protocol at concentrations of 0, 5.0, 25, and 100mg/kg/day. The reproduction/developmental screen employed a satellite group of females. Increased hyaline droplet formation but no nephropathy was observed in kidneys of all groups of treated male rats. Doses of 25 and 100mg/kg produced minimal morphological changes in the thyroids (follicular cell atrophy) of males and subchronic females. No neurobehavioral effects were observed. NOAEL for systemic toxicity [excluding HDE for males] in both sexes was 5mg/kg/day.

MCPD Dimer was tested orally by gavage according to the OECD 422 protocol at concentrations of 0, 20, 100, and 300mg/kg/day. The reproduction/developmental screen employed a satellite group of females. Increased hyaline droplet formation but no nephropathy was observed in kidneys of all groups of treated male rats. Clinical signs of toxicity, decreased body weight and weight gain, decreased feed consumption, decreased motor activity and histopathological (follicular thyroid cell atrophy) changes were observed at 300mg/kg in both sexes. Effects on body weight, clinical signs and feed consumption were also seen at 100mg/kg in both sexes and at 20mg/kg clinical signs of toxicity were seen in male rats. The NOAEL for females was 20mg/kg and was <20mg/kg for males.

Repeated inhalation exposure of rats to MCPD Dimer [Dodd and Longo, 1982] in a 12-day study (9 days exposure, 3 days recovery) at concentrations of 0, 5, 50 or 404ppm produced male rat specific hyaline droplet nephropathy and increased liver mitotic index in males rats resulting in a

NOAEL less than 5ppm. NOAEL in female rats was 50ppm. In mice at the same doses, the male NOAEL = 5ppm due to hematologic effects, increased liver weight and mitotic figures observed at 50ppm and above; female NOAEL = 50ppm due to hematologic effects, increased liver and kidney weights at 404ppm.

Subcategory 2

High DCPD Resin Oil was tested in a 12-day rat inhalation study (9 days exposure, 3 days recovery) at concentrations of 0, 0.6 and 2.5g/m^3. Exposure at 0.6g/m^3 resulted in arched back and convulsions for both sexes and increased liver weight in females. Increased production of hyaline droplets was observed in all groups of treated male rats. A NOAEL was not established.

Dermal administration of High DCPD Resin Oil to rats in a 14-day study (9 days treatment, 5 days recovery) at doses of 0, 1.0, and 2.0g/kg/day induced mild to moderate skin effects and slight hematological changes at 2.0g/kg but no overt signs of systemic toxicity. Kidneys of all treated male rats showed increased production of hyaline droplets. NOAEL based on dermal effects for both sexes = 1.0g/kg.

Subcategory 3

Low DCPD Resin Oil was tested orally by gavage according to the OECD 422 protocol at concentrations of 0, 35, 125, and 375mg/kg/day. The reproduction/developmental screen employed a satellite group of females. Increased hyaline droplet formation but no nephropathy was observed in kidneys of all groups of treated male rats. Slight increase in minimal thyroid follicular cell atrophy was observed in male rats in the 375mg/kg group. NOAEL was 35mg/kg for both sexes based on decreased thymus weight without associated histopathology at 125 and 375mg/kg for males [in females at 375mg/kg] and minimal to mild hepatocellular hypertrophy and associated increased liver weights at 125 and 375mg/kg for females [in males at 375mg/kg]. No neurobehavioral effects were observed.

Conclusion

In general, all of the tested streams produced a similar spectrum of subchronic toxicological effects: mild neurological effects during treatment, low but occasional mortality, male rat hydrocarbon-induced hyaline droplet increases in kidneys with or without overt nephropathy (HDE), liver hypertrophy with concomitant indications of increased liver enzyme activity, mild histopathological effects on liver, kidney and thyroid, decreased body weight/body weight gain with decreased feed consumption, and occasional alterations in one or several hematological parameters. Distinction in degree of potency for the various streams are indicated by the NOAELs and the parameters used to establish the NOAELs. HDE was excluded from determining NOAELs as a species and sex specific syndrome not considered relevant to human health.

Oral: The results of the OECD 422 systemic toxicity segment illustrate the range of toxicity.

- Subcategory 1: Three streams were tested from this 6-stream group: DCPD high purity. DCPD/Codimer Concentrate, and MCPD Dimer. The NOAELs for toxicity to the males (HDE excluded) for these streams were 4, 5, and <20mg/kg/day, and for the females 20, 5 and 20mg/kg day, respectively.
- Subcategory 3: One stream, Low DCPD Resin Oil was tested. The NOAELs for both male and females was 35mg/kg/day.

Thus, for these effects the stream from subcategory 3 was somewhat less potent as a toxicant than were the streams of subcategory 1. It is anticipated that the 2 untested streams of subcategory 2 would have potencies between those of 1 and 3.

Inhalation/Dermal:

- Subcategory 1: DCPD high purity was evaluated for systemic toxicity in 13 week studies both rats and mice. Similar effects were observed as in the oral OECD 422 studies. NOAELs for males and females were 1 and 51ppm respectively for rats and 5.1ppm for both sexes of mice.
- Subcategory 2: High DCPD Resin Oil produced neurological symptoms by inhalation (arched back, convulsions) at $0.6 g/m^3$ in a 12-day study and no NOAEL was obtained. Dermal administration produced effects similar to those of the subcategory 1 streams in both males and females with a NOAEL = 1.0g/kg.

The subchronic findings (with the exception of the neurological symptoms produced by inhalation of High DCPD Resin Oil) indicate that the toxicities of the 3 subcategories seen in various tests are similar, differing primarily in potency despite differences in chemical composition. It is likely that toxicity is driven primarily by the concentrations of DCPD and MCPD Dimer, the concentrations of which are inversely related to the presence of other components.

4.1.3 Mutagenicity

In vivo Studies

Three of the 4 representative product streams tested orally in the mouse micronucleus assay did not induce cytogenetic damage at any dose level. NOELs for these 3 streams were the highest dose tested.

Subcategory 1: DCPD/Codimer Concentrate NOEL = 1750mg/kg

MCPD Dimer produced equivocal results in the assay. When data were analysed by male and female separately, no statistically significant increase in micronuclei was observed; when sexes were combined, results were statistically significant at $p < 0.05$. Increases were of low potency and fell within the range of historical negative control values.

Subcategory 2: High DCPD Resin Oil NOEL = 500mg/kg

Subcategory 3: Low DCPD Resin Oil NOEL = 1750mg/kg

In vitro Studies

All representative product streams tested in the *Salmonella* or *E. coli* bacterial assays for gene mutation produced negative results with or without metabolic activation.

Subcategory 1: DCPD high purity, DCPD/Codimer Concentrate, MCPD Dimer: Negative +/-S9

Subcategory 3: Low DCPD Resin Oil: Negative +/-S9

Subcategory 2: High DCPD Resin Oil was tested for gene mutation in the mammalian Chinese hamster ovary cell line and did not induce mutant colonies with or without metabolic activation, nor was unscheduled DNA synthesis, indicative of DNA damage and repair, induced in rat hepatocytes in culture. However in another assay, High DCPD Resin Oil caused cell transformation of BALB-c cells in culture. DCPD was tested *in vitro* for cytogenetic damage but did not cause chromosome aberrations in Chinese hamster lung cells with or without metabolic activation.

Conclusion

Overall, product streams in the 3 chemical subcategories of the Resin Oils and Cyclodiene Dimer Concentrates Category do not induce gene mutations or significant cytogenetic damage in standard assays. The observations of increased micronucleus formation by MCPD Dimer in mouse bone marrow were within the range of historical control data and were statistically significant only for combined data and cannot be considered definitive.

4.1.4 Toxicity for Reproduction and Development

Effects on Fertility and Development

Four product streams were tested by the oral route in the OECD 422 Combined Repeat Dose Toxicity Study with Reproduction/Developmental Screening to fully characterize the toxicity of the category for purposes of the HPV program. Three streams came from subcategory 1: DCPD, DCPD/Codimer Condensate and MCPD Dimer, and 1 from Subcategory 3: Low DCPD Resin. For these studies, systemic toxicity results were discussed in Section 4.1.2 above. Additional developmental range-finding studies and a 3-generation reproductive toxicity study has been performed with DCPD. This section summarizes studies for which robust summaries are provided in Attachment 1b.

Subcategory 1

DCPD High Purity was tested orally by gavage according to the OECD 422 protocol at concentrations of 0, 4, 20 and 100mg/kg/day in rats (JETOC, 1998). Dams and 2 litters were lost during lactation in the 100mg/kg group [Cause not identified]. Pups exhibited low birth weight and low weight gain and had a low viability index. The NOAEL for developmental and reproductive endpoints = 20mg/kg. DCPD was not selectively toxic to rodent reproduction or to the developing embryo/fetus.

Developmental toxicity range-finding studies were conducted by NTP in New Zealand White rabbits and Sprague-Dawley rats (Gulati *et al*., 1993a,b). DCPD administered by gavage at 25, 100, 200, 300, or 400 mg/kg to rabbits caused maternal toxicity at 200 mg/kg and higher doses. One abortion occurred in the 100mg/kg group. Gross deformities were evident at 400 mg/kg but no other developmental endpoints were significantly affected. The NOAEL for dams was 25mg/kg and for pups was 300mg/kg. Rats were administered DCPD at 50, 200, 300, 400, and 500 mg/kg by gavage. Body weights of dams were significantly decreased at gestation days 8 and 10 in the 50mg/kg group and from days 8-20 in the 200mg/kg and 300mg/kg [1 rat] groups Dose related decreases in body weight gain were seen throughout treatment for rats in the 50 and 200 mg/kg groups. Clear maternal toxicity, including maternal death, was observed at 200 mg/kg and higher doses (3/7 in the 200 mg/kg group, 8/9 in the 300 mg/kg group, and all in the 400 and 500 mg/kg groups were found dead by gestation day 9). Dams showed decreased body weight gain down to 50mg/kg. Developmental toxicity in the form of decreased fetal weight was observed in the 200 mg/kg group; NOAEL developmental = 50mg/kg. No full-scale studies were performed from these range-finding studies.

A 3-generation reproduction study of DCPD High Purity, administered to rats in the diet at 80 and 750 ppm resulted in no deleterious effects on reproductive processes or general condition of the rats and no evidence of dose-related teratologic effect over 3 successive generations with 2 matings per generation. NOAEL = 750ppm. In an accompanying rat teratology study, no effects on pregnant dams from dietary administration of 80, 250, or 750 ppm DCPD and no compound-induced terata, variation in sex ratio, embryo toxicity or inhibition of fetal growth and development was observed. NOAEL = 750ppm

DCPD/Codimer Concentrate was tested orally by gavage according to the OECD 422 protocol at concentrations of 0, 5.0, 25, and 100mg/kg/day. No statistically significant effects were observed for developmental or reproductive parameters at any dose level. NOAEL = 100mg/kg

MCPD Dimer was tested orally by gavage according to the OECD 422 protocol at concentrations of 0, 20, 100, and 300mg/kg/day. Dams showed decreased body weight gain at 300mg/kg during gestation but not during lactation, which did not affect mating, fertility, delivery or lactation and nurturing behavior. Pups exhibited low birth weight and low weight gain at 100 and 300mg/kg but no adverse effects were seen on number of pups, survival or viability index.
NOAEL developmental = 20mg/kg. NOAEL reproduction = 300mg/kg

Subcategory 3

Low DCPD Resin Oil was tested orally by gavage according to the OECD 422 protocol at concentrations of 0, 35, 125, and 375mg/kg/day. Dams showed decreased body weight and body weight gain during gestation and lactation at 375mg/kg, which did not affect mating, fertility, delivery or lactation and nurturing behavior. Pups exhibited low body weight at 375mg/kg but no adverse effects were seen on number of pups, survival or viability index. NOAEL developmental = 125mg/kg. NOAEL reproduction = 375mg/kg.

Conclusion

Three streams of subcategory 1 and 1 stream of subcategory 3 have been evaluated for effects on reproduction. In the subchronic portion of the OECD 422 studies, the 3 streams from subcategory 1 and the stream from subcategory 3 produced systemic toxicity that permitted determination of NOAELs and LOAELs. However, pup toxicity, expressed primarily as low body weight and low body weight gain, was found only for DCPD high purity and MCPD Dimer. DCPD/Codimer Concentrate of subcategory 1 and Low DCPD resin oil had NOAELs of 100 and 125mg/kg/day, respectively. Thus, an evaluation of toxicity versus composition for effects on pup toxicity could be conducted (Table 11).

Table 11. Comparison of Developmental Toxicity NOAELs with Content of DCPD and MCPD Dimer in Representative Streams of the Resin Oils and Cyclodiene Dimer Concentrates Category

Stream	% MCPD Dimer	% DCPD	% TOTAL	Pup NOAEL [mg/kg/day]
DCPD High Purity	--	97.0	97	20
MCPD Dimer	90.0	0.1	90.1	20
DCPD/Codimer Concentrate	9.6	41.0	50.6	100
Low DCPD Resin Oil	--	0.5	0.5	125

Thus, developmental toxicity was correlated with the concentrations of DCPD and MCPD Dimer across the different categories, and it is likely that developmental toxicity would be correlated with the concentrations in the untested streams as well.

4.2 Assessment Summary for Human Health Effects

Existing data are sufficient to characterize human health hazards for substances included in the Resin Oils and Cyclodiene Dimer Concentrates Category for purposes of the HPV program. The 9 process streams in this category were divided into 3 subcategories based on the content of aliphatic cycloalkenes and aromatic components. Subcategory 1 contained 6 streams with high aliphatic content (DCPD and/or MCPD Dimer; 98-99+%). Subcategory 2 contained 2 streams that were 39-70% aliphatics and 30-65% aromatics. Subcategory 3 contained a stream with low DCPD content (<5%) and high aromatic content (95%).

All streams demonstrated minimal to mild acute toxicity regardless of chemical component distribution. None of the streams were likely to induce significant genetic toxicity *in vitro* or *in vivo*. In general, all of the tested streams produced a similar spectrum of subchronic toxicological effects: mild neurological effects during treatment, low but occasional mortality, male rat specific hydrocarbon induced hyaline droplet increases in kidneys with or without overt nephropathy, mild changes in liver, kidney and thyroid, decreased body weight/body weight gain with decreased feed consumption, and occasional alterations in one or several hematological parameters. In the reproductive/developmental area, reproductive performance was largely unaffected, and low pup body weight and weight gain were the major developmental effects.

Differences in degree of toxic response correlated with chemical composition became evident for repeat dose and reproduction/developmental endpoints. The oral OECD 422 Combined Repeat Dose Toxicity Study with Reproduction/Developmental screening was performed on representative streams for subcategories 1 and 3. In the subchronic toxicity segment of the OECD studies, the streams of subcategory 1 [DCPD high purity, DCPD/Codimer Concentrate, and MCPD Dimer] exhibited no effect levels between 4 and 20 mg/kg/day, while Low DCPD Resin Oil of subcategory 3 had the highest NOAEL = 35mg/kg/day for toxicity in males. Because of the different doses with wider ranges between doses used for testing different streams, the NOAELs for DCPD, DCPD/Codimer Concentrate, and MCPD Dimer are considered to be similar. Low DCPD Resin Oil from subcategory 3, however, appeared somewhat less toxic than those of subcategory 1. These results are similar to those observed for females as well. It is likely that the transition of "no effect" to "effect" within subcategory 1 would occur at doses around 20mg/kg/day. Neither of the streams in subcategory 2 was tested but it is likely that these streams would produce effects intermediate to those of subcategories 1 and 3.

In addition to toxicity to the parental rats that was observed in the OECD 422 studies, effects were also observed on the pups. As anticipated DCPD High Purity and MCPD Dimer of subcategory 1 produced similar degrees of toxicity. NOAELs for these streams occurred at 20mg/kg/day. Also, as anticipated, Low DCPD Resin Oil of subcategory 3 was less toxic with a NOAEL of 125mg/kg/day. DCPD/Codimer Concentrate of subcategory 1 which contained substantially less cyclodiene dimer, was much less toxic to pups (NOAEL = 100mg/kg) than were streams DCPD or MCPD Dimer, suggesting that additional evaluation of composition versus toxic effect is warranted. Thus, as illustrated in Table 11 (above) it appears that within subcategory 1, developmental toxicity expressed primarily as low pup weight and low weight gain, is related to, and may be predicted by the sum of MCPD Dimer and DCPD levels in the streams.

The results of these studies demonstrate that the subcategory designations developed on chemical composition are consistent with toxicity data and that the overall results for these product streams justifies the designation of the Resin Oils and Cyclodiene Dimer Concentrates as a category for HPV.

5. HAZARDS TO THE ENVIRONMENT

5.1 Aquatic Effects

<u>Acute Toxicity</u>

The aquatic toxicity of streams in this category is expected to fall within a relatively narrow range regardless of their composition. This is expected because the constituent chemicals of these streams are neutral organic hydrocarbons whose toxic mode of action is non-polar narcosis. The toxic mechanism of short-term toxicity for these chemicals is disruption of biological membrane function (Van Wezel, 1995), and the differences between toxicities (i.e., LC/LL_{50}, EC/EL_{50}) can be explained by the differences between the target tissue-partitioning behavior of individual constituent chemicals (Verbruggen *et al.*, 2000).

The existing fish toxicity database for hydrophobic, neutral organic chemicals, which compose the streams in this category, supports a critical body residue (CBR) for these chemicals between approximately 2 to 8 mmol/kg fish (wet weight) (McCarty *et al.*, 1991; McCarty and Mackay, 1993). The CBR is the internal concentration of a toxicant that causes mortality. When normalized to lipid content for most organisms, the CBR is approximately 50 µmol/g of lipid (Di Toro *et al.*, 2000). Therefore, only hydrocarbon streams with components of sufficient water solubility, such that their molar sum in solution is high enough to produce a total partitioning to the organism of approximately 50 µmol of hydrocarbon per gram of lipid will demonstrate lethality.

Aquatic toxicity data are available for products in the Resin Oils and Cyclodiene Dimer Concentrates Category, as well as read across data from chemicals found in products from this category and comparably complex products to fully characterize the toxicity of this category for purposes of the HPV program. The use of data from selected read across materials to products in this category can be justified for the following reasons:

- Individual chemicals and complex products used for read across purposes contain a chemical class or combinations of chemical classes that are found in streams from this category.
- Individual chemicals and complex products used for read across purposes have a carbon number or carbon number range that falls within the range of carbon numbers found in streams from this category.
- Individual chemicals and complex products used for read across purposes as well as the streams in this category are composed of chemicals that all act by a similar mode of toxic action.

The data in Appendix 5, Table A5-1 provides a comparison of the range of product compositions (i.e., carbon number, chemical class, weight percent) in the Resin Oils and Cyclodiene Dimer Concentrates Category to products that have been used to help characterize the aquatic toxicity of this category. This comparison illustrates the similarity in carbon number ranges between products in this category and the selected products with read across data. To confirm the range of aquatic toxicity for products in this category, data were developed for DCPD/Codimer Concentrate, Low DCPD Resin Oils and MCPD Dimer. The DCPD/Codimer Concentrate and Low DCPD Resin Oil products contain mid range and low concentrations of DCPD, respectively. The remaining chemical constituents for these 2 products vary in composition, but can include a selection of chemicals listed in Table A5-1. The majority of chemicals in these products have carbon numbers in the range of 8 to 10. The MCPD Dimer stream was selected because unlike most other products in this category, it is a relatively pure product and represents the highest molecular weight compounds in the range of chemical carbon numbers found in this category. Fish toxicity data for 2 species were also available for Resin Former Feedstock, a product stream with 7% DCPD and higher aromatic content.

The data in Appendix 5, Tables A5-2 (Fish), A5-3 (Daphnia), and A5-4 (Algae) establish a range of toxicity for products in this category. Generally, the fish, invertebrate, and alga studies followed the OECD Guidelines 203, 202, and 201, respectively. For complex products, the test procedures used to develop the test material exposure solutions also applied the OECD guidance described in "Guidance Document on Aquatic Toxicity Testing of Difficult Substances and Mixtures" (OECD, 1999). For these studies, the results are represented as lethal loading (LL) endpoints, a designation used to define results for multi-hydrocarbon mixtures, tested as water accommodated fractions [WAF], compared to the data developed for pure chemicals, which represent results as lethal concentration endpoints where test material is analytically verified.

For representative chemicals and Resin Oils and Cyclodiene Dimer Concentrate products, experimental acute fish toxicity values range between 2.6 to 18.0 mg/L except for DCPD/Codimer Concentrate which induced toxicity at a slightly lower concentration of 0.73mg/L (Table A5-2). For acute invertebrate (*Daphnia*) toxicity, values ranged between 1.0 to 21.3 mg/L with DCPD/Codimer Concentrate again inducing toxicity at a slightly lower concentration (Table A5.3). The greater toxicity to fish and *Daphnia* observed with DCPD/Codimer Concentrate may result from a distribution of codimers other than DCPD. Toxicity to one algal species was fairly similar for all chemical/products evaluated at 72 and 96 hours, ranging between loading rates of 0.65 to 2.9mg/L (for biomass or growth rate endpoints), and alga loading rate NOELR values ranged between 0.17 to 1.1 mg/L (for biomass and growth rate endpoints). Toxic effects on algae at 96 hours exposure based on measured concentrations ranged from 0.42 to 2.0mg/L (for biomass and growth rate endpoints) and no observed effect measured concentrations (NOEC) of 0.096 to 0.37mg/L (Table A5-4). MCPD Dimer demonstrated similar alga toxicity to the other product streams tested; therefore fish and invertebrate studies were not performed with this material. Toxicity results for the other aquatic species will be read-across. [Robust summaries are in Attachment 1c].

Because the products in this category are all complex mixtures containing relatively similar series of homologous chemicals [alkenes, olefins and/or aromatic carbon number content within approximately C4-C12], their short-term toxicities are expected to fall within the range of toxicity demonstrated by the individual chemicals, and tested products. The existing data are believed to form a sufficiently robust dataset to fully characterize the aquatic toxicity endpoints in the HPV Chemical Program for the Resin Oils and Cyclodiene Dimer Concentrates Category.

5.2 Assessment Summary for the Environment

The environmental impact of products in the Resin Oils and Cyclodiene Dimer Concentrates Category has been determined by evaluating data developed for representative process streams and chemical components found in the products in this category. The hydrocarbons that comprise this category have a very low potential to hydrolyze and do not photodegrade directly due to a minimal capacity to absorb appreciable light energy above 290nm. However, atmospheric oxidation constitutes a significant route of degradation. Calculation of atmospheric half-lives of representative constituent chemicals identified a range of 0.7 to 53.0 hours as a result of indirect hydrolysis by hydroxyl radical attack. Fugacity modelling demonstrated that members of this category partition primarily into the air, or into air, soil and water, and minimal partitioning into sediment. These products are not readily biodegradable and have the potential to produce a high to moderate level of toxicity in freshwater algae and a high to moderate level of acute toxicity in freshwater fish and invertebrates. The consistency of results in environmental studies for these materials justifies the designation of Resin Oils and Cyclodiene Dimer Concentrates as a category for HPV.

6. PROGRAM SUMMARY AND RECOMMENDATIONS

The Resin Oils and Cyclodiene Dimer Concentrates Category has addressed 9 related petrochemical process streams derived from pyrolysis gasoline by the ethylene manufacturing process and identified by 10 CAS numbers. These streams are isolated intermediates transferred under controlled conditions for use as reactive intermediates in the production of resins, or blended with other streams to produce fuel oils. Because they are used only as intermediates, no consumer uses are known for the category streams. The streams are liquid at room temperature. The most likely routes of human exposure are inhalation of vapors generated from evaporation, dermal contact, or possible oral ingestion from ground water contamination following a spill. However, since streams are transferred between industrial sites, stored and used inside closed systems, the possibility of occupational and public exposure to Resin Oils and Cyclodiene Dimer Concentrates is very low. Moreover, the category streams are mixtures of volatile organic compounds (VOC) and are therefore subject to USEPA and state environmental regulations that limit VOC emissions. Tables 12 and 13a and 13b respectively, summarize the Human Health, Physicochemical, and Environmental data compiled to characterize the streams in the Resin Oils and Cyclodiene Dimer Concentrates category.

Human Health Effects: For toxicological evaluation, the 9 product streams in this category were divided into 3 subcategories based on the content of aliphatic cycloalkenes and aromatic components. Subcategory 1 contained 6 streams with high aliphatic content (98-99+%) – DCPD, High purity, DCPD Concentrate, MCPD Dimer, DCPD Purge Stream, DCPD/Codimer concentrate and DCPD stream; subcategory 2 contained 2 streams that were 39-70% aliphatics and 30-65% aromatics - High DCPD resin oil and Resin Former Feedstock; subcategory 3 contained a stream with low DCPD content (<5%) and high aromatic content (95%)- Low DCPD Resin Oil. Testing was performed on representative streams of subcategory 1 and 3 to determine if extremes of the category ranges yielded significantly different toxicological effects. Results of these studies evaluated with already available data on other streams and selected chemicals that are present in these streams have made it possible to develop a toxicological and environmental profile of the Resin Oils and Cyclodiene Dimer Concentrates Category.

The streams of the Resin Oils and Cyclodiene Dimer Concentrates Category demonstrated minimal to mild acute toxicity regardless of chemical component distribution. None of the streams induced significant genetic toxicity *in vitro* or *in vivo*. A similar spectrum of subchronic toxicological effects was demonstrated by all tested streams by any route of exposure and included mild neurological effects during treatment, changes in body weight and feed consumption, and organ effects in liver, thyroid and kidney. Male rats demonstrated the species and sex-specific hydrocarbon-induced hyaline droplet increases in the kidney with and without overt nephropathy, a syndrome considered not to be relevant to human health hazard (USEPA, 1991). Overall reproductive parameters were unaffected by exposure to representative resin oils and cyclodiene dimer concentrates; developmental effects were expressed primarily as low pup weight at birth and during lactation, and low pup weight gain and usually occurred when maternal weight was also affected. However, MCPD Dimer did induce decreased pup weight at a lower dose than that at which maternal weight was affected. Differences in degree of toxic responses that correlated with chemical composition were evident, particularly for developmental effects, and appeared to be related to and predictable from DCPD and MCPD Dimer levels in the process streams.

Physicochemical, Environmental and Aquatic Endpoints: For environmental endpoints, measured data on representative process streams, components present in the products of the Resin Oils and Cyclodiene Dimer Concentrates Category, and on other complex products that contain a similar range of chemical classes and carbon numbers were used. Where measured data do not exist, calculated data for selected constituents of these streams have been developed using the EPIWIN© computer models described by EPA. The hydrocarbons that comprise this category have a very low potential to hydrolyze and do not photodegrade directly due to a minimal capacity to absorb appreciable light energy above 290nm. However, atmospheric oxidation constitutes a significant route of degradation. Calculation of atmospheric half-lives of representative constituent chemicals identified a range of 0.7 to 53.0 hours as a result of indirect hydrolysis by hydroxyl radical attack. Fugacity modelling demonstrated that members of this category partition primarily into the air, or into air, soil and water, and minimal partitioning into sediment. Streams or components of these streams are slightly soluble in water and groundwater contamination is possible if spills or leaks occur from production, transportation or storage equipment. These products are not readily biodegradable and have the potential to produce a high to moderate level of toxicity in freshwater algae and a high to moderate level of acute toxicity in freshwater fish and invertebrates.

The extensive body of data available for mammalian and environmental endpoints on selected constituents of products in this category, and on representative process streams of the Resin Oils and Cyclodiene Dimer Concentrates Category, are sufficient to fully characterize the potential toxicity for materials in this category for purposes of the HPV program and demonstrate the integrity of the category. No additional testing is needed to meet the requirements of the HPV program.

Table 12. Human Health Data Used to Characterize Streams and CAS RNs in the Resin Oils and Cyclodiene Concentrates Category

Endpoint	Resin Oils and Cyclodiene Concentrates Category Streams and CAS RNs		
	Subcategory 1	**Subcategory 2**	**Subcategory 3**
	77-73-6 (DCPD high purity) **68478-10-4 (DCPD/Codimer Concentrate)** **2647-00-4 (MCPD Dimer)** **68527-24-2 (DCPD Purge Stream)** **68477-53-2 (DCPD Stream)** **68478-08-0 + 68527-26-4 + 68603-02-1 (DCPD Concentrate)**	**68477-54-3 + 68477-40-7 (High DCPD Resin Oil)** **68477-54-3 (Resin Former Feedstock)**	**68477-54-3 + 68516-20-1 (Low DCPD Resin Oil)**
Acute Toxicity (oral, rat)	0.35 to > 10g/kg (RA, a)	0.96g/kg (RA, e)	>2.0g/kg
Acute Toxicity (dermal, rabbit)	>3.16g/kg (RA, b)	>2.0g/kg (RA, e)	>2.0 g/kg (RA, b, e)
Acute Toxicity (inhalation, rat)	284 to >495ppm (RA, a)	>5.4g/m^3 (RA, e)	1.65g/m^3
Repeat Dose Toxicity (oral; NOAEL, rat) OECD 422	4 to 20mg/kg systemic 100-300mg/kg neurotoxicity (RA, c)	4 to 35mg/kg systemic 100 to 375 mg/kg neurotoxicity (RA, d)	35mg/kg systemic 375mg/kg neurotoxicity
Genetic Toxicity *in vitro*	Negative: Ames, E. coli Negative (cytogentics) CH lung (RA, c)	Negative: CH ovary; UDS Positive: BALB 3T3 (RA, e)	Negative: Ames; E. coli
Genetic Toxicity *in vivo*	Negative to Equivocal (MN) (RA, c)	Negative (MN) (RA, e)	Negative (MN)
Reproductive Toxicity rat (oral NOAEL) OECD 422 3-generation, rat (diet)	20mg/kg to 300mg/kg (RA, c) 750ppm (DCPD High Purity)	100 to 375mg/kg (RA, f)	375mg/kg
Developmental Toxicity (NOAEL) OECD 422	20 to 100mg/kg (RA, c)	100 to 125mg/kg (RA, g)	125mg/kg

CH - Chinese Hamster; **UDS -** Unscheduled DNA Synthesis; **BALB/3T3 -** Mouse Embryo Cell Transformation Assay; Ames - Ames Salmonella Mutagenicity Assay; **MN -** Mammalian Bone Marrow Erythrocyte Micronucleus; **RA** =Read across

a = Based on test results for 77-73-6 (DCPD, High Purity) and 2647-00-4 (MCPD Dimer)
b = Based on test results for 2647-00-4 (MCPD Dimer)
c = Based on test results for 77-73-6 (DCPD, High Purity) 2647-00-4 (MCPD Dimer), and 68478-10-4 (DCPD/Codimer Concentrate
d = Based on test results for 77-73-6 (DCPD High Purity), 68478-10-4 (DCPD/Codimer Conc., 2647-00-4 (MCPD Dimer) and 68477-54-3 +68516-20-1 (Low DCPD Resin Oil)
e= Based on test results for 68477-54-3 + 68477-40-7 (High DCPD Resin Oil)
f = Based on test results for 68478-10-4 (DCPD/Codimer Conc.), 2647-00-4 (MCPD Dimer) and 68477-54-3 +68516-20-1 (Low DCPD Resin Oil)
g = Based on test results for 68478-10-4 (DCPD/Codimer Concentrate, and 68477-54-3 +68516-20-1 (Low DCPD Resin Oil)

Table 13a. Physico-Chemical and Environmental Data Used to Characterize Streams and CAS RNs in the Resin Oils and Cyclodiene Concentrates Category

Endpoint	Resin Oils and Cyclodiene Concentrates Category Streams and CAS RNs		
	Subcategory 1	**Subcategory 2**	**Subcategory 3**
	77-73-6 (DCPD high purity) 68478-10-4 (DCPD/Codimer Concentrate) 2647-00-4 (MCPD Dimer) 68527-24-2 (DCPD Purge Stream) 68477-53-2 (DCPD Stream) 68478-08-0 + 68527-26-4 + 68603-02-1 (DCPD Concentrate)	**68477-54-3 + 68477-40-7 (High DCPD Resin Oil) 68477-54-3 (Resin Former Feedstock)**	**68477-54-3 + 68516-20-1 (Low DCPD Resin Oil)**
Boiling Point Range (°C @760 mm Hg)	150.0 to 197.0 (m)	120.42 to 231.75 (a, c)	174 to 193 (m)
Vapor Pressure Range (hPa @ 25 °C)	0.80 to 19.0 (m)	0.25 to 20.53 (a, c)	41.0 (m)
Log P_{ow} Range (25 °C)	3.2 to 5.9 (m)	2.48 to 3.42 (a, c)	3.1 to 4.7 (m)
Melting Point/ Range (°C)	32.0 (m)	-60.33 to 35.06 (a,c)	
Water Solubility/ Range (mg/L @ 25 °C)	0.62 to 51.9 (c)	51.9 to 935 (a,c)	
Direct Photodegradation	Direct Photolysis will not contribute to degradation		
Indirect (OH-) Photodegradation (half-life, hrs)	0.7 to 1.1 (b,c,d)	0.7 to 53.0 (a,c,d)	
Hydrolysis	Hydrolysis will not contribute to degradation		
Distribution (c)	86 to 98% partitions to air; 0.1 to 0.9% to water; 1 to 14% to soil; <0.1% to sediment	32 to 98% partitions to air; 1 to 31% to water; 1.0 to 47% to soil; <0.1 to1.0% to sediment (a)	

(a) Constituent chemicals used to define selected endpoints include: vinyl toluene, indene, methyl indene, dicyclopentadiene, and methylcyclopentadiene dimer.
(b) Constituent chemicals used to define selected endpoints include: dicyclopentadiene, and methylcyclopentadiene dimer.
(m) Measured values (c) Calculated values (d) Atmospheric half-life values are based on a 12-hr day.

Table 13b. Physico-Chemical and Environmental Data Used to Characterize Streams and CAS RNs in the Resin Oils and Cyclodiene Concentrates Category

Endpoint	Resin Oils and Cyclodiene Concentrates Category Streams and CAS RNs		
	Subcategory 1	**Subcategory 2**	**Subcategory 3**
	77-73-6 (DCPD high purity) **68478-10-4 (DCPD/Codimer Concentrate)** **2647-00-4 (MCPD Dimer)** **68527-24-2 (DCPD Purge Stream)** **68477-53-2 (DCPD Stream)** **68478-08-0 + 68527-26-4 + 68603-02-1 (DCPD Concentrate)**	**68477-54-3 + 68477-40-7 (High DCPD Resin Oil)** **68477-54-3 (Resin Former Feedstock)**	**68477-54-3 + 68516-20-1 (Low DCPD Resin Oil)**
Biodegradation	0 after 28 days (RA, a)	0 to 6.4 after 41 days (RA, d)	6.4 after 41 days
96-hr Fish LC50/ LL50 (mg/L)	0.58 to 3.7/ 0.73 (RA, c)	n.a/ 10.6 to 13.5 (RA, e)	6.1/ 6.3
48-hr Invertebrate EC50/ EL50 (mg/L)	0.76/ 0.91 to 10.5 (RA, c)	0.76 to 2.9/ 0.91 to 10.5 (RA, f)	2.9/ 3.2
96-hr Algae EC50/ EL50 (mg/L)	0.42 to 1.2/ 0.65 to 1.6 b 0.83 to 1.0/ 1.2 to 1.4 r (RA, a)	0.42 to 1.9/ 0.65 to 2.1 b 0.83 to 1.4/ 1.2-1.5 r (RA, d)	1.9/ 1.9 b 1.4/ 1.5 r
96-hr Algae NOEC/NOELR (mg/L)	0.096 to 0.14/ 0.17b 0.096 to 0.30/ 0.17 to 0.47 r (RA, a)	0.096 to <0.27/ 0.17 to <0.23 b 0.09 to 0.94/ 0.17 to 1.1 r (RA, d)	<0.27/ <0.23 b 0.94/ 1.1 r

RA = Read-across; n.a. = data not available:
a = Based on test results for 68478-10-4 (DCPD/Codimer Concentrate) and 2647-00-4 (MCPD Dimer)
b = biomass; r = growth rate
c = Based on test results for 77-73-6 (DCPD, High Purity) and 68478-10-4 (DCPD/Codimer Concentrate
d = Based on test results for 68478-10-4 (DCPD/Codimer Concentrate, 2647-00-4 (MCPD Dimer) and 68477-54-3 +68516-20-1 (Low DCPD Resin Oil)
e= Based on test results for 68477-54-3 + 68477-40-7 (High DCPD Resin Oil)
f = Based on test results for 77-73-6 (DCPD, High Purity) and 68478-10-4 (DCPD/Codimer Conc. and 68477-54-3 +68516-20-1 (Low DCPD Resin Oil)

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Appendix 1: Ethylene Process Description

1. Steam Cracking

Steam cracking is the predominant process used to produce ethylene. Various hydrocarbon feedstocks are used in the production of ethylene by steam cracking, including ethane, propane, butane, and liquid petroleum fractions such as condensate, naphtha, and gas oils. The feedstocks are normally saturated hydrocarbons but may contain minor amounts of unsaturates. These feedstocks are charged to the coils of a cracking furnace. Heat is transferred through the metal walls of the coils to the feedstock from hot flue gas, which is generated by combustion of fuels in the furnace firebox. The outlet of the cracking coil is usually maintained at relatively low pressure in order to obtain good yields to the desired products. Steam is also added to the coil and serves as a diluent to improve yields and to control coke formation. This step of the ethylene process is commonly referred to as "steam cracking" or simply "cracking" and the furnaces are frequently referred to as "crackers".

Subjecting the feedstocks to high temperatures results in the partial conversion of the feedstock to olefins. In the simplest example, feedstock ethane is partially converted to ethylene and hydrogen. Similarly, propane, butane, or the liquid feedstocks are also converted to ethylene. While the predominant products produced are ethylene and propylene, a wide range of additional products are also formed. These products range from methane (C1) through fuel oil (C12 and higher) and include other olefins, diolefins, aromatics and saturates (naphthenes and paraffins).

2. Refinery Gas Separation

Ethylene and propylene are also produced by separation of these olefins from refinery gas streams, such as from the light ends product of a catalytic cracking process or from coker offgas. This separation is similar to that used in steam crackers, and in some cases both refinery gas streams and steam cracking furnace effluents are combined and processed in a single finishing section. These refinery gas streams differ from cracked gas in that the refinery streams have a much narrower carbon number distribution, predominantly C2 and/or C3. Thus the finishing of these refinery gas streams yields primary ethylene and ethane, and/or propylene and propane.

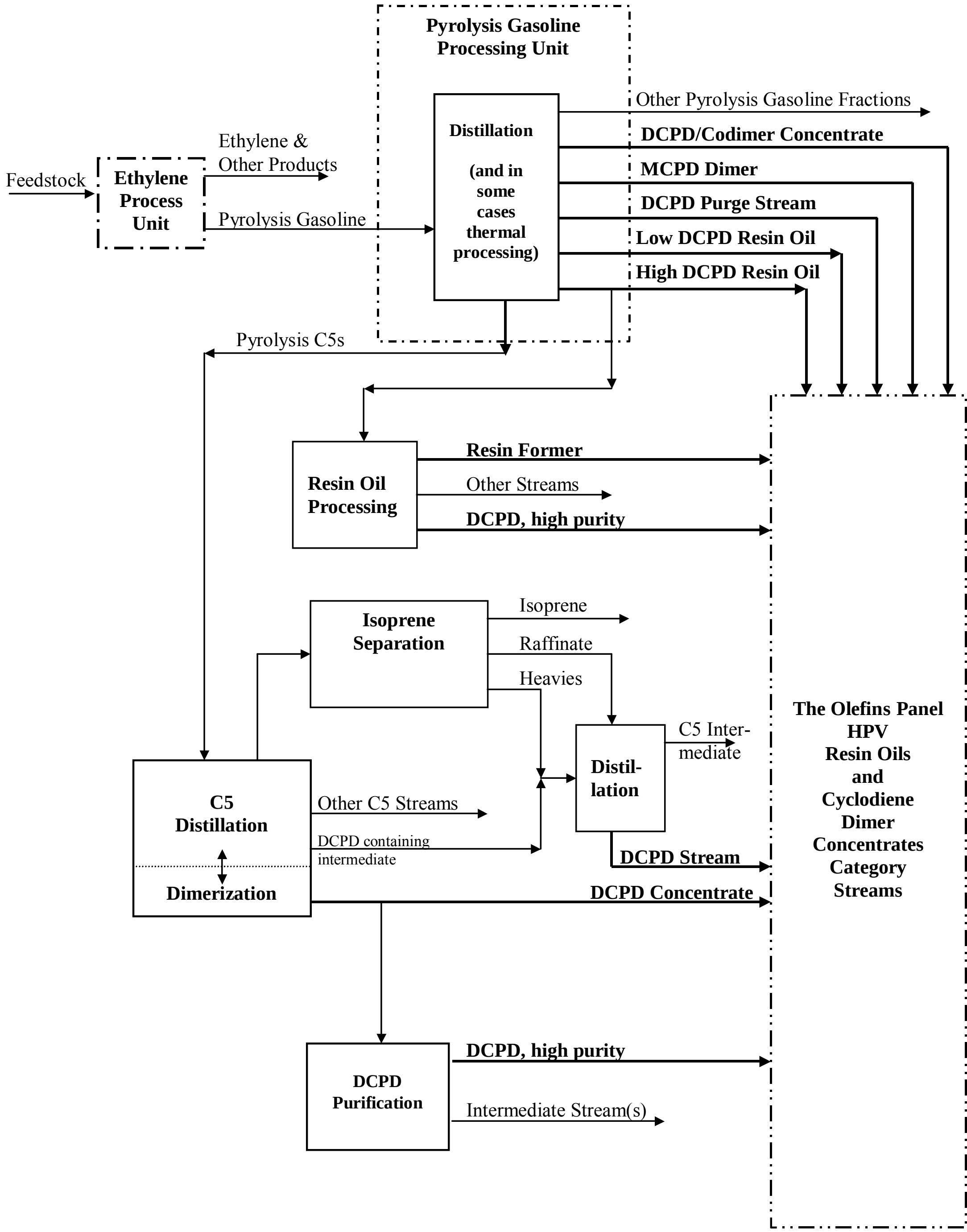
Products of the Ethylene Process

The intermediate stream that exits the cracking furnaces (i.e., the furnace effluent) is forwarded to the finishing section of the ethylene plant. The furnace effluent is commonly referred to as "cracked gas" and consists of a mixture of hydrogen, methane, and various hydrocarbon compounds with two or more carbon atoms per molecule (C2+). The relative amount of each component in the cracked gas varies depending on what feedstocks are cracked and cracking process variables. Cracked gas may also contain relatively small concentrations of organic sulfur compounds that were present as impurities in the feedstock or were added to the feedstock to control coke formation. The cracked gas stream is cooled, compressed and then separated into the individual streams of the ethylene process. These streams can be sold commercially and/or put into further steps of the process to produce additional materials. In some ethylene processes, a liquid fuel oil product is produced when the cracked gas is initially cooled. The ethylene process is a closed process and the products are contained in pressure systems.

The final products of the ethylene process include hydrogen, methane (frequently used as fuel), and the high purity products ethylene and propylene. Other products of the ethylene process are typically mixed streams that are isolated by distillation according to boiling point ranges and then further processed. It is a subset of these mixed streams that make up the constituents of the Resin Oils and Cyclodiene Dimer Concentrates Category.

The chemical process operations that are associated with the process streams in the Resin Oils and Cyclodiene Dimer Concentrates Category are shown in Figure A1-1.

Figure A1-1. Chemical Process Operations Associated with Process Streams in the Resin Oils and Cycodiene Dimer Concentrates Category.



Appendix 2
Typical Composition Ranges (Percent) for
Resin Oils and Cyclodiene Dimer Concentrates Streams.
(See notes 1-3 at the end of this table)

Component Name	High DCPD Resin Oil	Low DCPD Resin Oil	Resin Former	DCPD Conc.	DCPD, High Purity	MCPD Dimer	DCPD Purge	DCPD Stream	DCPD/ Codimer Conc.
Isoprene (2-Methyl-1,3-Butadiene)				0.5					
Pentane				1 - 1.5					
Cis-2-Pentene				3.5					
1,3-Cyclopentadiene	2			0 - 3	0.2 - 1.5				
1,3-Pentadiene				3					
Cyclopentene				4.8					
Cyclopentane				0.8 - 1					
C5 Olefins and Paraffins								35 - 45	
C6-C8 Non-Aromatics				1 - 7					
CPD or MCPD Codimers with Vinyl Aromatics			8.2						
Benzene	0 – 0.01			0 - 2.5		0.01			
C7 Cyclics						1			
Toluene				0 - 2					
Xylenes, Mixed		1 - 5	1.2						
Styrene	2 - 6	0 - 11	4.5						
Allylbenzene			2.5						
Propylbenzene	0.5 - 1	1.4	2						
C9 Substituted Benzenes		20							
Ethyltoluenes	1 - 2.5	4	7						
1,3,5-Trimethylbenzene (Mesitylene)	0 - 1								
Alpha-Methylstyrene	0.5 - 3.5	1 - 5	4.5						
o-,p-,m-Methylstyrene		12							
1,2,4-Trimethylbenzene (Pseudocumene)		1 - 10							
Trimethylbenzenes	1 - 2.3	5 - 20	4						
Cyclopentadiene/Isoprene Codimers	0 - 1								
Cyclopentadiene/1,3-Pentadiene Codimers	0.6 - 1.6								9.9
Piperylene-MCPD Codimers									5.7
Butadiene-CPD Codimers									6.3
Butadiene-MCPD Codimers							6		
Isoprene-cyclopentadiene codimers				11					
Cyclopentadiene / Methylcyclopentadiene Codimers	1 - 7		5.3				10		24
Dicyclopentadiene	40 - 70	0.5	6.7	70 - 90	94 – 99.5	0.1	18		41
DCPD and codimers of C5s								55-60	
MCPD-C7 Codimers							5		
C5-MCPD Codimers							18		
C5-CPD Codimers							5		
Tetrahydro-Indiene							5		
C8 aliphatics and aromtics							10		
Vinyl Toluene	4 – 14	5 - 25	13.6						

Component Name	High DCPD Resin Oil	Low DCPD Resin Oil	Resin Former	DCPD Conc.	DCPD, High Purity	MCPD Dimer	DCPD Purge	DCPD Stream	DCPD/ Codimer Conc.
Vinyl Aromatics	10								
Isobutylbenzene			1.4						
Remaining C8+ Olefins and Aromatic Components, Including Various Oligimers of CPD and MCPD	2.5 - 15								
C10 & C11 Codimers of C5 & C6					0.2 - 4				
Propenylbenzene		1.5							
Beta-Methylstyrene	0.5 - 1.5	1 - 5	6.4						
Indane (Indan)		1 - 1.5							
C10 Substituted Benzenes		3 - 7							
Indene	2 - 9	5 - 20	13.4						
Butylbenzene	0 - 1.5		2						
C10 Substituted Styrene		4 - 10							
Dimethylstyrene		2.1							
Methyl Indenes		5 - 30	1.1						
Methyl Indane		1							
C10-C11 Alkylbenzenes		10 - 30							
Methylcyclopentadiene Dimers	0.5 - 1.2		5.2			90	18		9.6
Acyclic Dienes					2 - 2.3	1			
Trimers				1.1	0 - 2		4		2.4
Naphthalene	0.5	1 - 8	1						
C6 - C9 Saturates								0 - 5	

NOS not otherwise specified

Note 1: The composition data shown above are composites of reported values.
Note 2: The balance of these streams is expected to be other hydrocarbons that have boiling points in the range of the listed components.
Note 3: The listed highs and lows should not be considered absolute values for these limits. They are instead the highs and lows of the reported values.

Appendix 3. Summary Results of Health Effects Data for Streams in the Resin Oils and Cyclodiene Dimer Concentrates Category

Streams by Sub-category	Stream identification	Acute Toxicity	Genetic Point Mutations *in vitro*/Other Genetic Effects	Genetic Chromosome aberrations [*in vivo & in vitro*]	Subchronic Toxicity	Developmental Toxicity	Reproductive Toxicity
1	DCPD High purity	Inhalation LC50 rat [male] = 284ppm; [female] = 353ppm Inhalation LC50 mice [male] = 143ppm; [female] = 130ppm Oral LD50 rat = 346-820mg/kg [from ECETOC, 1991]	*Salmonella/E.coli* = negative +/- S9	*In vitro*[CH lung] = negative =/- S9 No *in vivo* data	OECD 422 rat oral 0, 4, 20, 100mg/kg/day NOAEL [M] = 4mg/kg [exclude HDE] NOAEL [F]= 20mg/kg Inhalation. Rat 13 wk 0, 1.0, 5.1, 51ppm NOAEL [M] = 1ppm [exclude HDE] NOAEL [F]= 51ppm Inhalation. Mice 13 wk NOAEL [M & F] = 5.1ppm LOAEL [M & F]= 51ppm [20% deaths; no other major effects]	OECD 422 rat oral 0, 4, 20, 100mg/kg/day NOAEL dam=20mg/kg [2 litters lost in lactation] NOAEL pups=20mg/kg [low birth wt and gain; low viability index] Oral rat Range finding study. in corn oil 0, 50, 200, 300, 400, 500mg/kg/day NOAEL dam= NE NOAEL pups= 50mg/kg [dec. fetal wt.] Oral rat diet 0, 80, 250, 750ppm NOAEL dams & pups =750ppm Oral rabbit Range finding study in corn oil 0, 25, 100, 200,300, 400mg/kg NOAEL dam =25mg/kg NOAEL pup=300mg/kg [deaths, deformities at 400mg/kg]	OECD 422 rat oral 0, 4, 20, 100mg/kg/day NOAEL dams & pups = 20mg/kg NOAEL males = 100mg/kg 3 generation (diet) rat 0, 80, 750ppm NOAEL all =750ppm
1	DCPD/Codimer Concentrate,	None	*Salmonella/E.coli* = negative +/- S9	*In vivo* mice, oral Micronucleus Negative; NOAEL = 1750mg/kg	OECD 422 rat oral 0, 5, 25, 100mg/kg/day NOAEL [M] = 5mg/kg [exclude HDE] NOAEL [F]= 5mg/kg [thyroid follicular cell atropy] Neurotoxicity [M&F] NOAEL=100mg/kg	OECD 422 rat oral 0, 5, 25, 100mg/kg/day NOAELdevel=100mg/kg	OECD 422 rat oral 0, 5, 25, 100mg/kg/day NOAELparental=100mg/kg NOAELpup=100mg/kg

NE= not established; HDE= increased incidence of hyaline droplets seen in kidneys of male rats; species and sex specific, not significant for human toxicity

Appendix 3. Summary Results of Health Effects Data for Streams in the Resin Oils and Cyclodiene Dimer Concentrates Category (cont.)

Streams by Sub-category	Stream identification	Acute Toxicity	Genetic Point Mutations *in vitro*/Other Genetic Effects	Genetic Chromosome aberrations [*in vivo & in vitro*]	Subchronic Toxicity	Developmental Toxicity	Reproductive Toxicity
1	MCPD Dimer	Inhalation LC50 rat [M&F] > 495 ppm Inhalation LC50 mice [M&F] > 450 ppm; Oral LD50 rat >10g/kg [lethargy, ataxia,diarrhea] Dermal LD50 rabbit >3.16g/kg [lethargy, ataxia,irritation]	*Salmonella/E.coli* = negative +/- S9	*In vivo* mice, oral Micronucleus: 0, 500, 1000 &2000mg/kg Equivocal : positive for M&F combined; bone marrow toxic at 1000 & 2000mg/kg Negative for males & females separately	OECD 422 rat oral 0, 20, 100, 300mg/kg/day NOAEL [M] < 20mg/kg [exclude HDE] NOAEL [F]= 20mg/kg Neurotoxicity: Males =100mg/kg [decreased MA] Females= 300mg/kg Inhalation. Rat 12 day 0, 5,50 [0.29g/m^3], 404ppm [2.38g/m^3 NOAEL [M] < 5ppm [increased liver mitotic index and HDE] NOAEL [F]= 50ppm Inhalation. Mice 12 day NOAEL [M] = 5ppm NOAEL [F] = 50ppm LOAEL [M]=50ppm [hematology effects, increased liver wt and mitotic fig.] LOAEL [F]=404ppm [hematology effects, increased. liver & kidney wt]	OECD 422 rat oral 0, 20,100,300mg/kg/day NOAEL devel=20mg/kg [low pup birth wt and gain]	OECD 422 rat oral 0, 20,100,300mg/kg/day NOAEL parental= 300mg/kg [decreased dam wt gain during gestation but not lactation, did not affect mating or delivery] NOAELpups=300mg/kg [dec wt gain did not affect # of pups or survival]

NE= not established. MA = Motor activity:
HDE= increased incidence of hyaline droplets seen in kidneys of male rats; species and sex specific, not significant for human toxicity

Appendix 3. Summary Results of Health Effects Data for Streams in the Resin Oils and Cyclodiene Dimer Concentrates Category (cont.)

Streams by Sub-category	Stream identification	Acute Toxicity	Genetic Point Mutations *in vitro*/Other Genetic Effects	Genetic Chromosome aberrations [*in vivo & in vitro*]	Subchronic Toxicity	Developmental Toxicity	Reproductive Toxicity
2	High DCPD Resin Oil	Inhalation LC50 rat [M&F] > 5.4g/m^3 Oral LD50 rat Male >0.56 < 1.8g/kg Female=0.97g/kg [M&F] =0.96g/kg Dermal LD50 rabbit >2.0g/kg	CHO cell mut = negative+/-S9 Unscheduled DNA synthesis in rat hepatocytes: negative. Transformation BALB-c cells = Positive	*In vivo* mice, oral Micronucleus Negative; NOAEL = 500mg/kg	Inhalation. Rat 12 day 0, 06, 2.5g/m^3 NOAEL = NE LOAEL [M & F] =0.6g/m^3 [arched back, convulsions; inc liver wt in females; HDE in males]. Dermal. Rat 14 day 0, 1.0, 2.0g/kg NOEL dermal 1.0g/kg LOEL dermal=2.0g/kg no overt systemic toxicity [excludes HDE]	None	None
3	Low DCPD Resin Oil Also defined as C9 Resin oil	C9 Resin oil Inhalation LC50 rat Males = 1.40mg/L Females = 1.90mg/L [M & F] = 1.65mg/L Oral LD50 rat >2g/kg Irritation rabbit Eye – strong Skin - mild	C9 Resin Oil & Low DCPD Resin Oil *Salmonella/E.coli* = negative +/- S9	Low DCPD Resin Oil *In vivo* mice, oral Micronucleus Negative NOAEL= 1750mg/kg	OECD 422 rat oral 0, 35, 125, 375mg/kg/day NOAEL [M] = 35mg/kg [dec. thymus; exclude HDE NOAEL [F]= 35mg/kg [inc. liver wt] Neurotoxicity: [M & F] = 375mg/kg	OECD 422 rat oral 0, 35,125,375mg/kg/day NOAELdevel=125mg/kg [low pup body wt]	OECD 422 rat oral 0, 35,125,375mg/kg/day NOAEL parental = 375mg/kg [dec. dam wt gain during gestation and lactation, did not affect mating, or delivery] NOAELpups=375mg/kg [dec wt did not affect # of pups or survival]

NE= not established. MA = Motor activity
HDE= increased incidence of hyaline droplets seen in kidneys of male rats; species and sex specific, not significant for human toxicity

Appendix 4. Biodegradation

Biodegradability Data of Selected Chemicals, Chemically Complex Products, and Several Products in the Resin Oils and Cyclodiene Dimer Concentrates Category.

[The Data are for Chemicals Contained by Products in this Category and Chemically Complex Products not in this Category. The complex products contain chemicals found in products from this category.]

CHEMICAL / PRODUCT	CARBON NUMBER	PERCENT BIODEGRADATION(a) (28 days)	REFERENCE
Alkenes, C7-C9, C8 Rich	7-9	29	HOP*
o-Xylene	8	70	IHSC**
p-Xylene	8	89	IHSC**
Styrene	8	100 (14 days)(c)	***
C8-C10 Aromatics, Predominantly C9 Alkylbenzenes	9 (b)	78	IHSC**
C8-C14 Aromatics, Predominantly Alkyl Naphthalenes and Naphthalene	10-12 (b)	61	IHSC**
DCPD Codimer Concentrate	8-12 (b)	0	Robust summary provided with this test plan
MCPD Dimer	8-12 (b)	0	Robust summary provided with this test plan
Low DCPD Resin Oil	8-12 (b)	6.4 (41 days) 44 (56 days;acclimated inoculum)	Robust summary provided with this test plan

a OECD 301F, manometric respirometry test
b Predominant carbon number or range
c BOD test
* Robust summary from the Higher Olefins Panel: C6, C7, C8, C9, and C12 Internal Olefins and C16 and C18 Alpha Olefins Category Test Plan (submitted)
** Robust summary from the International Hydrocarbon Solvents Consortium: Contained in selected SIAR (to be submitted)
******* Chemicals Inspection and Testing Institute, Japan. 1992.

Appendix 5. Aquatic Toxicity

Table A5-1

Approximate Weight Percent and Carbon Number Range Comparison of the Predominant Hydrocarbons in Products from the Resin Oils and Cyclodiene Dimer Concentrates Category and Chemically Complex Products with Aquatic Toxicity Data used to Read Across to the Category.

(The complex products are not in this category.)

Substance Name	Olefins		Aromatics		Paraffins	
	% (wt.)	**C # (a)**	**% (wt.)**	**C # (a)**	**% (wt.)**	**C # (a)**
Products in Resin Oils and Cyclodiene Dimer Concentrates Category (b)	**1-34**	**5-9**	**>40-100**	**6-11**	**>4-75**	**5-10**
Alkenes, C7-9, C8 Rich	**100**	**7-9**	**0**	**-**	**0**	**-**
C8-C10 Aromatics, Predominantly C9 Aromatics	**0**	**-**	**>97**	**8-10**	**<3**	**-**
C8-C14 Aromatics, Predominantly Alkyl Naphthalenes and Naphthalene	**0**	**-**	**>94**	**10-14**	**<6**	**-**

a Predominant carbon number range

b Approximate weight percent and carbon number ranges of the predominant chemical components for products contained by this category; % compositions may not total 100%.

Table A5-2

Acute Fish Toxicity Data for Selected Chemicals, Chemically Complex Products, and several Products in the Resin Oils and Cyclodiene Dimer Concentrates Category

[The Chemical and Complex Product Data are used to Read Across to Products from the Resin Oils and Cyclodiene Dimer Concentrates Category].

CHEMICAL / PRODUCT	CARBON NUMBER	ORGANISM	AQUATIC TOXICITY (a) (96-hr, mg/L)	REFERENCE
Alkenes, C7-9, C8 Rich	7-9(b)	*Oncorhynchus mykiss*	LL50 = 8.9	HOP*
o-Xylene	8	*Pimephales promelas*	LC50 = 16.4	IHSC**
p-Xylene	8	*Oncorhynchus mykiss*	LC50 = 2.6	IHSC**
p-Xylene	8	*Pimephales promelas*	LC50 = 8.9	IHSC**
Ethylbenzene	8	*Pimephales promelas*	LC50 = 12.1	IHSC**
High DCPD Resin Oil	8-10(b)	*Oncorhynchus mykiss*	LL50 = 10.6	Robust summary provided with this test plan
High DCPD Resin Oil	8-10(b)	*Lepomis macrochirus*	LL50 = 13.5	Robust summary provided with this test plan
1,2,4-Trimethylbenzene	9	*Pimephales promelas*	LC50 = 7.7	IHSC**
C8-C10 Aromatics, Predominantly C9 Aromatics	8-10(b)	*Oncorhynchus mykiss*	LL50 = 18.0	IHSC**
Dicyclopentadiene	10	*Oryzias latipes*	LC50 = 3.7(c)	Robust summary provided with this test plan
DCPD/Codimer Concentrate	8-12	*Oncorhynchus mykiss*	LC50 = 0.58 LL50 = 0.73	Robust summary provided with this test plan
Low DCPD Resin Oil	8-12	*Oncorhynchus mykiss*	LC50 = 6.1 LL50 = 6.3	Robust summary provided with this test plan
C8-C14 Aromatics, Predominantly alkyl Naphthalenes and Naphthalene	10-12(b)	*Oncorhynchus mykiss*	LL50 = 3.0	IHSC**

a Endpoint is mortality; LC = Lethal Concentration; LL = Lethal Loading; NOELR = No Observed Effect Loading Rate; values cited as "concentration" are based on measured values
b Predominant carbon number or range
c 48-hour study
* Robust summary from the Higher Olefins Panel: C6, C7, C8, C9, and C12 Internal Olefins and C16 and C18 Alpha Olefins Category Test Plan (submitted)
** Robust summary from the International Hydrocarbon Solvents Consortium: Contained in selected SIAR (to be submitted).

Table A5-3
Acute Invertebrate Toxicity Data for Selected Chemicals, Chemically Complex Products and Several Products in the Resin Oils and Cyclodiene Dimer Concentrates Category.

[The Chemical and Complex Product Data are used to Read Across to Products from the Resin Oils and Cyclodiene Dimer Concentrates Category.]

CHEMICAL / PRODUCT	CARBON NUMBER	ORGANISM	AQUATIC TOXICITY (a) (48-hr, mg/L)	REFERENCE
o-Xylene	8	*Daphnia magna*	EC50 = 1.0	IHSC*
m-Xylene	8	*Daphnia magna*	EC50 = 4.7	IHSC*
C8-C10 Aromatics, Predominantly C9 Aromatics	8-10(b)	*Daphnia magna*	EL50 = 21.3	IHSC*
Naphthalene	10	*Daphnia magna*	EL50 = 16.7(c)	IHSC*
Dicyclopentadiene	10	*Daphnia magna*	EL50 = 10.5(c)	Robust summary provided with this test plan
DCPD/Codimer Concentrate	8-12	*Daphnia magna*	EL50 = 0.91 EC50 = 0.76	Robust summary provided with this test plan
Low DCPD Resin Oil		*Daphnia magna*	EL50 = 3.2 EC50 = 2.9	Robust summary provided with this test plan
C8-C14 Aromatics, Predominantly Alkyl Naphthalenes and Naphthalene	10-12(b)	*Daphnia magna*	EL50 = 3.0	IHSC*

a Endpoint is immobility; EC = Effect Concentration; EL = Effect Loading; NOELR = No Observed Effect Loading Rate; values cited as "concentration" are based on measured values

b Predominant carbon number or range

c Based on nominal values

* Robust summary from the International Hydrocarbon Solvents Consortium: Contained in selected SIAR (to be submitted)

Table A5-4

Alga Toxicity Data for Chemically Complex Products and Several Products in the Resin Oils and Cyclodiene Dimer Concentrates Category

[The Chemically Complex Product Data are used to Read Across to Products from the Resin Oils and Cyclodiene Dimer Concentrates Category.]

CHEMICAL / PRODUCT	CARBON NUMBER	ORGANISM	AQUATIC TOXICITY (a) Loading rates	AQUATIC TOXICITY (b) Measured conc.	REFERENCE
			(72-hr, mg/L)		
C8-C10 Aromatics, Predominantly C9 Aromatics	8-10 (b)	*Pseudokirchneriella subcapitata(c)*	EbL50 = 2.6 ErL50 = 2.9 NOELRb = 1.0 NOELRr = 1.0		IHSC*
C8-C14 Aromatics, Predominantly Alkyl Naphthalenes and Naphthalene	10-12 (b)	*Pseudokirchneriella subcapitata*	EbL50 = 1-3 ErL50 = 1-3 NOELRb = 1.0 NOELRr = 1.0		IHSC*
			(96-hr, mg/L)		
DCPD/Codimer Concentrate	8-12 (b)	*Pseudokirchneriella subcapitata*	EbL50 = 1.6 ErL50 = 1.4 NOELRb = 0.17 NOELRr = 0.47	EbC50 = 1.2 ErC50 = 1.0 NOECb = 0.14 NOECr = 0.30	Robust summary provided with this test plan
MCPD Dimer	8-12 (b)	*Pseudokirchneriella subcapitata*	EbL50 = 0.65 ErL50 = 1.2 NOELRb = 0.17 NOELRr = 0.17	EbC50 = 0.42 ErC50 = 0.83 NOECb = 0.096 NOECr = 0.096	Robust summary provided with this test plan
Low DCPD Resin Oil	8-12 (b)	*Pseudokirchneriella subcapitata*	EbL50 = 1.9 ErL50 = 1.5 NOELRb < 0.23 NOELRr = 1.1	EbC50 = 1.9 ErC50 = 1.4 NOECb <0.27 NOECr = 0.94	Robust summary provided with this test plan

a Endpoint is growth inhibition; EbL = Effect Loading for biomass; ErL = Effect Loading for growth rate; NOELRb = No Observed Effect Loading Rate for biomass; NOELRr = No Observed Effect Loading Rate for growth rate

b EbC = Effect on biomass based on measured concentration; ErC = Effect on growth rate based on measured concentration; NOEC b = No Observed Effect measured concentration for biomass; NOEC r = No Observed Effect measured concentration for growth rate

c Predominant carbon number

d Formally known as *Selenastrum capricornutum*

*Robust summary from the International Hydrocarbon Solvents Consortium: Contained in selected SIAR to be submitted)

Appendix 6.

American Chemistry Council

Olefins Panel Sponsored HPV Test Categories.

Category Number	Category Description
1	Crude Butadiene C4
2	Low Butadiene C4
3	C5 Non-Cyclics
4	Propylene Streams (C3) - Propylene sponsored through ICCA
5	High Benzene Naphthas
6	Low Benzene Naphthas
7, 8, & 9	Resin Oil & Cyclodiene Dimer Concentrates
10	Fuel Oils
11	Pyrolysis C3+ and Pyrolysis C4+

Attachments [Separate documents]

Attachment 1a. Robust Summaries: PhysicoChemical and Environmental Fate

Attachment 1b. Robust Summary: Mammalian Toxicology

Attachment 1c. Robust Summaries: Biodegradation and Aquatic Toxicology