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UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY (EPA)
HIGH PRODUCTION VOLUME (HPV)
CHEMICAL CHALLENGE PROGRAM

TEST PLAN

for the

HIGHER OLEFINS CATEGORY

Prepared by:

American Chemistry Council
Higher Olefins Panel

December 22, 2003

EXECUTIVE SUMMARY

The Higher Olefins Panel (Panel) of the American Chemistry Council and the Panel's member companies hereby submit for review and public comment the test plan for the Higher Olefins Category under the United States Environmental Protection Agency's (EPA) High Production Volume (HPV) Chemical Challenge Program. It is the intent of the Panel and its member companies to use new information in conjunction with a variety of existing data and scientific judgments/analyses to adequately characterize the OECD SIDS (Screening Information Data Set) human health, environmental fate and effects, and physicochemical endpoints for this category.

The category includes a non-continuous range of odd- and even-numbered mono-unsaturated olefins (C6 through C54) under 30 CAS numbers, 13 for alpha olefins and 17 for internal olefins. All CAS numbers are within the HPV Challenge Program. The C6 – C14 even-numbered linear alpha olefins were sponsored under the SIDS program (SIAM 11). The Panel has committed to sponsor the C6, C7, C8, C9, C10, C12 and C10-13 aliphatic linear and branched internal olefins and the C16 and C18 aliphatic linear alpha olefins in the ICCA HPV program.

The test plan is based on the expectation that internalizing the location of the carbon-carbon double bond, increasing the length of the carbon chain, and/or changing the carbon skeleton's structure from linear to branched does not change the toxicity profile, or changes the profile in a consistent pattern from lower to higher carbon numbers.

This plan addresses the category by examining relevant data at the upper and lower ends of the homologous series of Higher Olefins. At the lower end of the homologous series, three tests will be conducted with a C6 internal olefin stream (approximately 66% C6 alkenes, 18% C6 alkanes, 1% C7 alkenes, 2% C5 alkenes, 13% C5 alkanes, 58% branched alkenes) to include invertebrate acute toxicity, alga toxicity, and 28-day repeated dose rat oral/neuro/ reproduction/developmental toxicity screen (OECD 422). For the upper end of the homologous series, a rat oral reproduction/developmental toxicity screen (OECD 421) will be conducted with a C18 internal olefin (32.5% branched). In addition, to clarify the chronic toxicity to aquatic organisms, a chronic Daphnia reproduction test (OECD 211) will be conducted with a C10 alpha olefin. The results of these tests will be compared with available data for other homologs within the series of olefins. If the results from the above testing confirm that the toxicity profiles of all members of the Higher Olefins Category are essentially the same, or a pattern from lower to higher carbon numbers exists, any remaining data can be considered to fall within the ranges defined by the data and no further testing will be warranted. If the results do not confirm that hypothesis, a reassessment of the category will be conducted.

Predictive computer models will be used to develop relevant environmental fate and physicochemical data for chemicals in the Higher Olefins Category. Environmental fate information will be summarized either through the use of computer models when meaningful projections can be developed or in technical discussions when computer modeling is not applicable. For mixed streams, physicochemical properties will be represented as a range of values according to

component composition. These data will be calculated using a computer model cited in an EPA guidance document prepared for the HPV Challenge Program. In addition, readily available measured physicochemical data will be provided for selected product streams in this category.

American Chemistry Council

HIGHER OLEFINS PANEL

The Higher Olefins Panel includes the following member companies:

BP

Chevron Phillips Chemical Company LP

ExxonMobil Chemical Company

Shell Chemical Company

Shell Chemicals Ltd.

Sasol North America

Spolana a.s. Neratovice

Sunoco, Inc.

TABLE OF CONTENTS

TEST PLAN FOR THE HIGHER OLEFINS CATEGORY

TEST PLAN FOR THE HIGHER OLEFINS CATEGORY

I. INTRODUCTION

The Higher Olefins Panel (Panel) of the American Chemistry Council and the Panel's member companies have committed to develop screening level human health effects, environmental effects and fate, and physicochemical test data for the Higher Olefins Category under the United States Environmental Protection Agency's (EPA's) High Production Volume (HPV) Challenge Program (Program).

This plan identifies CAS numbers used to describe substances in the category, identifies existing data of adequate quality for substances included in the category, and outlines screening level data for this category under the Program. This document also provides the testing rationale for the Higher Olefins Category. The objective of this effort is to identify and develop sufficient test data and/or other information to characterize the human health and environmental effects and fate for the category in compliance with the EPA HPV Program. Physicochemical data that are requested in this program will be calculated as described in EPA guidance documents. In addition, readily available measured physicochemical data will be provided for selected product streams in this category.

II. BACKGROUND

Most higher alpha olefins are manufactured on a commercial scale by oligomerization of ethylene or propylene. The materials produced are mixtures including a range of molecular weights. These broad mixtures can be subsequently distilled into narrower mixtures or discrete chemical substances. The internal olefins are made from alpha olefins by isomerization or by isomerization/disproportionation, which can result in mixed chain length internal olefins. Oligomerization of ethylene generally leads to linear alpha olefins. Certain branched structures are also produced, typically as minor components, though levels increase with molecular weight and can be significant. Oligomerization of propylene generally produces branched alpha olefins. Various degrees of alkyl chain branching can be introduced by catalytic isomerization of linear olefins.

Two other routes to higher olefins are of commercial significance. Mixed alpha olefins are produced from synthesis gas (carbon monoxide and hydrogen) via Fischer-Tropsch type oligomerization. Internal olefins are produced from normal paraffins by partial catalytic dehydrogenation. Commercially valuable components are obtained via distillation or molecular sieve extraction followed by one or more purification steps.

Commercial higher olefins thus can range from narrowly defined substances to complex mixtures of alpha and internal, linear and branched olefins characterized by carbon range and physical properties.

III. DESCRIPTION OF THE HIGHER OLEFINS CATEGORY

The category includes a non-continuous range of odd- and even-numbered mono-unsaturated olefins (C6 through C54) under 30 CAS numbers, 13 for alpha olefins and 17 for internal olefins. All CAS numbers are within the HPV Challenge Program. The C6 – C14 even-numbered linear alpha olefins were sponsored under the SIDS program (SIAM 11). The Panel has committed to sponsor the C6, C7, C8, C9, C10, C12 and C10-13 aliphatic linear and branched internal olefins and the C16 and C18 aliphatic linear alpha olefins in the ICCA HPV program. The members of the category are presented in Table 1.

Table 1: Members of the Category

Alpha Olefins	**Branched/Linear**	**CAS No.**
Neohexene	Branched	558-37-2
1-Tridecene	Linear	2437-56-1
1-Hexadecene (ICCA)	Linear	629-73-2
1-Octadecene (ICCA)	Linear	112-88-9
1-Eicosene	Linear	3452-07-1
1-Docosene	Linear	1599-67-3
1-Tetracosene	Linear	10192-32-2
Alkenes, C10-16 alpha	Linear	68855-58-3
Alkenes, C14-18 alpha	Linear	68855-59-4
Alkenes, C14-20 alpha	Linear	68855-60-7
a-Olefin fraction C20-24 cut	Linear	93924-10-8
a-Olefin fraction C24-28 cut	Branched and Linear	93924-11-9
Alkene, C24-54 branched and linear, alpha	Branched and Linear	131459-42-2
Internal Olefins		
Hexene (ICCA)	Linear	25264-93-1
Heptene (ICCA)	Linear	25339-56-4
Octene (ICCA)	Linear	25377-83-7
Nonene (ICCA)	Linear	27215-95-8
Dodecene (ICCA – not sponsored in HPV)	Linear	25378-22-7
Alkenes, C6	Branched and Linear	68526-52-3
Alkenes, C6-8, C7 rich	Branched and Linear	68526-53-4
Alkenes, C7-9, C8-rich	Branched and Linear	68526-54-5
Alkenes, C8-10, C9-rich	Branched and Linear	68526-55-6
Alkenes, C9-11, C10-rich	Branched and Linear	68526-56-7
Alkenes, C10-12, C11-rich	Branched and Linear	68526-57-8
Alkenes, C11-13, C12-rich	Branched and Linear	68526-58-9
Heavy polymerization naphtha (petroleum)	Branched	68783-10-8

Alkenes, C10-16	Linear	68991-52-6
Alkenes, C15-C18	Linear	93762-80-2
C10,12 Olefin rich hydrocarbons	Linear	68514-32-9
C12,14 Olefin rich hydrocarbons	Linear	68514-33-0

The category is defined as Higher Olefins. This category consists of discrete chemicals with an incremental change across its members. This includes:

- Olefins with even and odd carbon numbers
- Both alpha and internal olefins, referring to the position of the olefinic double bond
- Linear and branched (alkyl side chains with no other functional groups included)

IV. EVALUATION OF EXISTING HEALTH EFFECTS DATA AND PROPOSED TESTING

A large body of data exists for aliphatic alpha and internal olefins (see Tables 8 and 9). Several of these olefins, the C6 – C14 alpha olefins (even carbon numbers), have previously been reviewed under the OECD SIDS High Production Volume Chemicals Program. The OECD recently reviewed these chemicals at SIAM 11 and concluded that the use of a category is appropriate for the alpha olefins. Building upon OECD work, a category approach is being utilized in the evaluation of the Higher Olefins. The existing mammalian toxicology data for the Higher Olefins have shown that the location of the double bond or the addition of branching to the structure do not appear to affect the toxicity. This is a fundamental principle of the Higher Olefins Category. The proposed testing along with the existing data, both discussed in this section, will provide the support for this category approach.

Olefins (alkenes) ranging in carbon number from C6 to C54, alpha (linear) and internal (linear and branched), demonstrate low acute toxicity by the oral, inhalation and dermal routes of exposure. Repeated-dose studies, using the inhalation (C6 alpha), dermal (C12-16 and C16 alpha), or oral (C6, C8 and C14 alpha; and C16/C18 and C20-24 internal linear/branched) routes of exposure, have shown comparable levels of low toxicity in rats. In females, alterations in body and organ weights, changes in certain clinical chemistry/hematology values, and liver effects were noted (NOELs of 100 mg/kg oral or 1000 ppm inhalation). In males, alterations in organ weights, changes in certain clinical chemistry/hematology values, liver effects, and kidney damage were noted (LOELs 100 mg/kg oral only). The male rat kidney damage seen in oral studies with C6, C8 and C14 linear alpha olefins, was not seen in studies with C16/C18 or C20-24 internal linear/branched olefins. While no specific immunohistochemical staining was conducted to identify the hyaline droplets associated with the observed kidney effects, their morphology and occurrence only in male rats suggests that they are probably related to $alpha_{2i}$-globulin nephropathy, a male rat specific effect that is not considered relevant to human health (Ref. 1 and 2). The noted liver effects were seen in oral studies with C14 alpha olefins (minimal-to-mild hepatocyte cytoplasmic vacuolation with increased liver weight in males and females) and with C20-24 internal olefins (minimal centrilobular hepatocyte hypertrophy with increased liver weight in females only). No effects were present in the study with C20-24 internal olefins following

a 4-week recovery period, indicating reversibility of the observed effects. These liver effects seen only with the larger molecules may be indirect effects of an intensified liver burden, rather than a direct toxic effect of the olefin (Ref. 3). Based on evidence from neurotoxicity screens included in repeated dose studies with C6 and C14 alpha olefins and with C16/C18 and C20-24 internal linear/branched olefins, the category members are not neurotoxic.

Many of the homologs within the series, both alpha and internal, and branched and linear, have been tested for genotoxicity. All studies except one were negative. A C6 branched and linear internal alkenes blend produced a weakly positive response in a mouse micronucleus study using oral administration. However, when the study was repeated using an inhalation route, the results were negative. The Ames Test was also negative. Mouse micronucleus tests with 1-hexene and with a C6-8, C7 rich, internal branched and linear alkenes blend were negative by the oral route of administration. Based on the weight of evidence, the compounds within the category are not genotoxic.

Based on evidence from reproductive/developmental toxicity screens in rats with C6 and C14 alpha olefins, along with the findings of no biologically significant effects on male or female reproductive organs in repeated-dose toxicity studies with C6 alpha olefin, and with C16/C18 and C20-24 linear/branched internal olefins, the category members will not cause reproductive or developmental toxicity.

The weight of evidence indicates alpha and internal olefins with carbon numbers between C6 and C54 have a similar low level of mammalian toxicity, and the toxicity profile is not affected by changes in the location of the double bond or the addition of branching to the structure.

To test the hypothesis, at the lower molecular weight end of the series, that internalizing the location of the double bond and/or changing the structure from linear to branched does not change the toxicity profile, the HPV battery of tests with an internal olefin at the low end of the category (C6 internal olefin stream containing approximately 66% C6 alkenes, 18% C6 alkanes, 1% C7 alkenes, 2% C5 alkenes, 13% C5 alkanes, 58% branched alkenes) will be completed for all mammalian toxicity endpoints and the results compared with available data for 1-hexene. To complete the HPV battery, an OECD 422 28-Day Repeated Dose Rat Oral/Neuro/Reproduction/ Developmental Toxicity Screening Test will be conducted. Adequate data exist for the other endpoints.

The Panel will also test this same hypothesis near the upper molecular weight end of the series by conducting an OECD 421 Rat Oral Reproduction/Developmental Toxicity Screening Test with a C18 mostly linear (32.5% branched) internal olefin. These results will be compared with similar data from an OECD 422 study on 1-tetradecene. These results will also be compared with data from an OECD 408 rat 90-day repeated-dose toxicity study with a C20-24 branched and linear (approximately 70% branched) internal olefins fraction. The OECD 421 test will also serve to confirm a lack of reproductive or developmental toxicity in the members near the upper end of the series. The C18 internal olefin that will be tested is not an HPV material and is not a member of the category; however, it is a component of one of the members of the category (Alkenes, C15-C18) and represents the upper end of the series of internal olefins within the category.

Since the upper end of the alpha olefin series of olefins is a waxy solid that is not likely to be bioavailable, and repeated dose toxicity and reproductive/developmental toxicity data exist for the more bioavailable C14 alpha olefin, testing of the C24 – C54 alpha olefin was not considered useful in characterizing the hazard potential of the category or appropriate, taking animal welfare considerations into account.

Summary:

Acute Toxicity: Acute toxicity studies exist for materials at both ends of the carbon number ranges in the series of olefins within this category and for many of the homologs within the series. The results are consistent throughout the category. Consequently, no acute toxicity testing is planned for this category.

Repeated-Dose and Reproductive/Developmental Toxicity: Repeated-dose toxicity studies exist for C6 and C8 alpha olefins and for C16/C18 (26% branched) and C20-24 (approximately 70% branched) blends of internal olefins. Combined repeated dose toxicity and reproduction/developmental toxicity screening studies exist for C6 and C14 alpha olefins. Results from alpha and internal olefins, whether linear or branched, or low or high carbon numbered, are consistent. A 28-day repeated-dose oral/neuro/reproduction/ developmental toxicity-screening test in rats (OECD 422) will be conducted with a C6 internal olefin stream (containing approximately 66% C6 alkenes, 18% C6 alkanes, 1% C7 alkenes, 2% C5 alkenes, 13% C5 alkanes, 58% branched alkenes). An oral reproduction/ developmental toxicity-screening test in rats (OECD 421) will be conducted with a C18 mostly linear (32.5% branched) internal olefin. The results from these tests will be compared with the existing data. If the results are consistent, these data will be considered adequate to address the potential repeated dose and reproduction/developmental toxicity health hazards of the category.

Genetic Toxicity: Tests for gene mutation and chromosome aberrations exist for C6 and C18 linear alpha olefins, for a C6 internal olefin stream (containing approximately 76% C6 alkenes, 16% C6 alkanes, 7% C7 alkenes, 60-74% branched), for a C20-24 internal olefins blend (70% branched), and for several of the homologs within those ranges. Based on the weight of evidence, these compounds are not genotoxic. No genetic toxicity testing is planned for this category.

V. EVALUATION OF EXISTING PHYSICOCHEMICAL AND ENVIRONMENTAL FATE DATA AND PROPOSALS FOR ADDRESSING THESE ENDPOINTS

Physicochemical Properties

Physicochemical data for each of the members of the Higher Olefins Category will be developed using the EPIWIN© model (Ref. 4), as discussed in the EPA document titled "The Use of Structure-Activity Relationships (SAR) in the High Production Volume Chemicals Challenge Program" (Ref. 5). In

addition, readily available measured physicochemical data will be provided for selected product streams in this category.

Biodegradation

Existing data show that selected chemicals in the Higher Olefins Category can biodegrade aerobically to a large extent within a few weeks and, for some chemicals, the data show that they fit the OECD criteria for ready biodegradability (Table 2). The C6 – C16 olefins have been shown to degrade to an extent of approximately 21 to 77% in standard 28-day biodegradation tests. Results of studies for two higher molecular weight olefins (a C18 linear alpha olefin and a C20-24 branched and linear internal olefin) suggest that the higher olefins have the potential to undergo significant biodegradation (>60%).

While, in total, biodegradation tests indicate the category is biodegradable and thus non persistent, the data vary over a wide range. Both structural features and test conditions can have an effect on biodegradation results. Carbon number, location of the double bond (internal vs. alpha) and branching are structural features that can affect biodegradability. Inoculum source and concentration, substrate concentration, and use of dispersants to enhance solubilization of poorly soluble compounds are examples of test conditions potentially affecting biodegradation results.

As far as structural features, carbon number would be expected to play a role in biodegradation from both solubility/bioavailability and steric effects. There is no clear correlation between carbon number and degree of biodegradation for alpha olefins. The internal olefins may exhibit increasing biodegradation with increasing carbon number, up to C24 (compare the C20-C24 with the C6-C12 results in Table 2). Overall, the data suggest double bond location to be more important than carbon number. Theoretically, the branched olefins might be expected to be less biodegradable. However, the existing data do not support this supposition. Testing in an OECD 301B test with a C20-24 branched and linear material (>70% branched) resulted in 92% degradation in 28 days. Both substrate and benzoate showed unusually high percent biodegradation (92 and nearly 100 %, respectively), suggesting some bias in the test. However, since both substrate and benzoate were biased the same way, the test still supports ready biodegradability of the substrate.

Location of the double bond in the alpha versus an internal position appears to play a role in biodegradability. The C6-C12 internal olefins have a lower percentage biodegradation while the higher carbon numbered internal olefins have, generally, a greater percent biodegradation (Table 2). Alpha olefin biodegradation appears to be insensitive to carbon number across the range tested. One literature source of general olefin biodegradability information makes a statement that the alpha olefins are favored over internal olefins (Ref. 6). This publication tabulates BOD/ThOD (Theoretical Oxygen Demand) data for example olefins, but the data do not support the text's statement since all the ratios fall in the same range.

A variety of OECD and ISO methods were used in the testing. The lower C6-C14 internal olefins were tested with 301F, while the C16 and greater were tested by other methods. All are acceptable methods, but this variety could account for some of the variability in the results. However, review of the

test conditions, as summarized in the robust summaries, does not highlight any systematic effects. The poor solubility of C8 and higher olefins make bioavailability a potential factor if the mass transfer effects impede biodegradation rates. However, most test conditions used either steady agitation or some form of dispersing medium to enhance solubilization during the test period. As far as test method effects are concerned, the source of inoculum is probably the greatest, and least controllable, source of variation.

Many of the tests reported in the C20+ range used a dispersant to improve solubility, and thus availability to the biota, of the test substance. However, at some point in the carbon number series, the solubility of these compounds may decrease to the extent that the biodegradation will not be observed, due purely to mass transfer limitations. It may not be practical to test up to C54 for this reason. With this limitation in mind, it doesn't appear that carbon number correlates well with biodegradability and we would expect the trend to continue, at least for the alpha olefins. The data are less consistent for internal olefins.

Additional estimates of biodegradability of the tested chemicals as well as with higher carbon number olefins were obtained using BIOWIN (Ref. 4) (Table 3). Both internal and alpha olefins were modeled. The BIOWIN estimations are consistent across carbon numbers (with the exception of the C30 and C40 non-linear probability method) and show the biodegradation trend extends to much higher carbon numbers than those tested.

Conclusions

- The Higher Olefins Category consists of inherently biodegradable compounds, with some meeting the readily degradable criterion.
- Bond location appears to play a role in biodegradability, with alpha olefins showing higher degradability than internal olefins.
- Test protocols vary, but no systematic bias in results can be observed from the data presented.
- Testing higher carbon numbers in the C24-C54 range would encounter some mass transfer limitation effect due to solubility, which would in turn reduce biodegradability results.
- Sufficient data are available to assess the potential biodegradability of this category. Therefore, no additional biodegradation tests will be conducted.

Table 2. Summary of Ready Biodegradability Tests for Olefins[1]

Chemical Substance	Alpha/Internal (AO/IO)	Method	Biodegradation at 28 Days (%)
CAS No. 592-41-6, 1-Hexene	AO	301C O2	77
CAS No. 592-41-6, 1-Hexene	AO	Closed Sturm CO2	22
CAS No. 68526-52-3 Alkenes, C6	IO	301F O2	21
CAS No. 68526-54-5; Alkenes, C7-9, C8 Rich	IO	301F O2	29
CAS No. 111-66-0, 1-Octene	AO	Closed Sturm CO2	41-42
CAS No. 68526-56-7; Alkenes, C9-11, C10 Rich	IO	301F O2	21
CAS No. 872-05-9, 1-Decene	AO	Manometric respirometry	81
CAS No. 68526-58-9, Alkenes, C11-13, C12 rich [C11-13]	IO	301F O2	23
CAS No. 68526-58-9, Alkenes, C11-13, C13 rich [C12-14]	IO	301F O2	8
CAS No. 85535-87-1, Alkenes C10-13	IO	301D O2	60-70
CAS No. 1120-36-1, 1-Tetradecene	AO	301D O2	62-65
CAS No. 1120-36-1, 1-Tetradecene	AO	301B CO2	48-56
CAS No. 629-73-2, 1-Hexadecene	AO	301C O2	55-77
CAS No. 112-88-9, 1-Octadecene	AO	301D O2	39-48
CAS No. 112-88-9, 1-Octadecene	AO	301B CO2	77-81
CAS No. 26952-14-7, Hexadecene; CAS No. 27070-58-2, Octadecene	IO	ISO Marine BODIS O2	48
CAS Nos. 182636-03-9, 182636-04-0, and 182636-05-1; C20-24 Alkenes, branched and linear	IO	301B CO2	92
CAS Nos. 182636-05-1; 182636-06-2, 182636-08-4; C24-30 Alkenes, branched and linear	IO	301B CO2	51

1 Study details and references are found in the robust summaries in the dossiers.

Table 3. Results of BIOWIN Modeling for Olefins

HPV olefins Biowin results								
Chemical	CAS No.	Carbon number	Linear biodeg probability*	Non-linear biodeg probability*	Ultimate biodeg#	Primary biodeg#	MITI linear biodeg probability^	MITI non-linear biodeg probability^
1-tetracosene	10192-32-2	24	0.70 fast	0.52 fast	2.8 weeks	3.6 days-weeks	0.77 readily degradable	0.87 readily degradable
4-tetracosene		24	0.80 fast	0.87 fast	3.1 weeks	3.9 days	0.71readily degradable	0.82 readily degradable
1-triacontene	18435-53-5	30	0.66 fast	0.25 does not biodeg fast	2.6 weeks-months	3.5 days-weeks	0.81 readily degradable	0.89 readily degradable
7-triacontene		30	0.76 fast	0.67 fast	2.9 weeks	3.8 days	0.76 readily degradable	0.84 readily degradable
1-tetracontene		40	0.59 fast	0.04 does not biodeg fast	2.3 weeks-months	3.3 days-weeks	0.89 readily degradable	0.91 readily degradable
6-tetracontene		40	0.70 fast	0.22 does not biodeg fast	2.6 weeks-months	3.6 days-weeks	0.84 readily degradable	0.87 readily degradable
C6 alkenes	68526-52-3	6	0.82 fast	0.97 fast	3.3 days-weeks	4.0 days	0.63 readily degradable	0.82 readily degradable
C7-9 alkenes, C8-rich	68526-54-5	8	0.80 fast	0.96 fast	3.2 weeks	4.0 days	0.64 readily degradable	0.82 readily degradable
C9-11 alkenes, C10-rich	68526-56-7	10	0.79 fast	0.95 fast	3.2 weeks	3.9 days	0.498 not readily degradable	0.53 readily degradable
C11-13 alkenes, C12-rich	68526-58-9	12	0.78 fast	0.92 fast	3.1 weeks	3.9 days	0.68 readily degradable	0.84 readily degradable
1-hexadecene	629-73-2	16	0.75 fast	0.84 fast	3.0 weeks	3.8 days	0.71 readily degradable	0.85 readily degradable
octadecene	27070-58-2	18	0.74 fast	0.78 fast	2.9 weeks	3.8 days	0.72 readily degradable	0.86 readily degradable
1-octadecene	112-88-9	18	0.74 fast	0.78 fast	2.9 weeks	3.8 days	0.72 readily degradable	0.86 readily degradable
* probability greater than or equal to 0.5 indicates biodegrades fast, probability less than 0.5 indicates does not biodegrade fast								
# primary and ultimate classification: 5.00 > hours, 4.00 > days, 3.00 > weeks, 2.00 > months, 1.00 > longer								
^ probability greater than or equal to 0.5 indicates readily degradable, probability less than 0.5 indicates not readily degradable								

Photodegradation, Hydrolysis, and Fugacity

The endpoints for photodegradation, hydrolysis, and fugacity will be either calculated or discussed. Chemical equilibrium models are used to calculate fugacity, which is only calculated. The lower homologs in the Higher Olefins category (C6 – C14) are calculated to partition primarily to the air, and therefore their fate in air is of environmental relevance (this aspect is discussed below under photodegradation). In addition, these components have relatively low Kow values, which suggests that they will not tend to partition to suspended organic matter in air and precipitate to aquatic and terrestrial compartments. The higher homologs in the category are calculated to partition primarily to the soil and sediment.

1. Photodegradation – Photolysis

Direct photochemical degradation occurs through the absorbance of solar radiation by a chemical substance. If the absorbed energy is high enough, then the resultant excited state of the chemical may

undergo a transformation. Simple chemical structures can be examined to determine whether a chemical has the potential for direct photolysis in water. First order reaction rates can be calculated for some chemicals that have a potential for direct photolysis using the procedures of Zepp and Cline (Ref. 7). UV light absorption of the substances in the category will be evaluated to identify those having the potential to degrade in solution. For those compounds with a potential for direct photolysis in water, first order reaction rates will be calculated.

2. Photodegradation – Atmospheric Oxidation

Indirect photodegradation can be measured (Ref. 8) (EPA identifies OECD test guideline 113 as a test method) or estimated using models accepted by the EPA (Ref. 5). An estimation method accepted by the EPA includes the calculation of atmospheric oxidation potential (AOP). Atmospheric oxidation is a result of hydroxyl radical attack and is not direct photochemical degradation, but rather indirect degradation. AOPs can be calculated using a computer model. Hydrocarbons, such as the majority of the chemicals in the Higher Olefins Category, readily volatilize to air. In air, chemicals may undergo reaction with photosensitized oxygen in the form of ozone and hydroxyl radicals. The computer program AOPWIN (atmospheric oxidation program for Microsoft Windows) (Ref.4) is used by OPPTS (the EPA's Office of Pollution Prevention and Toxic Substances). This program calculates a chemical half-life based on an overall hydroxyl radical (OH) reaction rate constant, a 12-hr day, and a given OH concentration. This calculation will be performed for the substances in the category.

3. Stability in Water (Hydrolysis Testing and Modeling)

Hydrolysis of an organic chemical is the transformation process in which a water molecule or hydroxide ion reacts to form a new carbon-oxygen bond. Chemicals that have a potential to hydrolyze include alkyl halides, amides, carbamates, carboxylic acid esters and lactones, epoxides, phosphate esters, and sulfonic acid esters (Ref. 9). Stability in water can be measured (Ref. 8) (EPA identifies OECD test guideline 111 as a test method) or estimated using models accepted by the EPA (Ref. 5). An estimation method accepted by the EPA includes a model that can calculate hydrolysis rate constants for esters, carbamates, epoxides, halomethanes, and selected alkylhalides. The computer program HYDROWIN (aqueous hydrolysis rate program for Microsoft windows) (Ref. 4) is used by OPPTS.

All of the chemical structures included in the Higher Olefins Category are simple hydrocarbons. That is, they consist entirely of carbon and hydrogen. As such they are not expected to hydrolyze at a measurable rate. A technical document will be prepared describing the potential hydrolysis rates of these substances, the nature of the chemical bonds present, and the potential reactivity of this class of chemicals with water.

4. Chemical Distribution in the Environment (Fugacity Modeling)

Fugacity based multimedia modeling can provide basic information on the relative distribution of chemicals between selected environmental compartments (i.e., air, soil, sediment, suspended sediment, water, biota). The EPA has acknowledged that computer modeling techniques are an appropriate

approach to estimating chemical partitioning (fugacity is a calculated endpoint and is not measured). A widely used fugacity model is the EQC (Equilibrium Criterion) Level I model (Ref. 10). EPA cites the use of this model in its document titled *Determining the Adequacy of Existing Data* (Ref. 8), which was prepared as guidance for the HPV Program.

In its document, EPA states that it accepts Level I fugacity data as an estimate of chemical distribution values. The input data required to run a Level I model include basic physicochemical parameters. Distribution is calculated as percent of chemical partitioned to 6 compartments (air, soil, water, suspended sediment, sediment, biota) within a unit world. Level I data are basic partitioning data that allow for comparisons between chemicals and indicate the compartment(s) to which a chemical is likely to partition.

The EQC Level I is a steady state, equilibrium model that utilizes the input of basic chemical properties including molecular weight, vapor pressure, and water solubility to calculate distribution within a standardized regional environment. This model will be used to calculate distribution values for substances in this category. A computer model, EPIWIN – version 3.02 (Ref. 4), will be used to calculate the properties needed to run the Level I EQC model.

Summary:

Physicochemical Properties: Physicochemical data will be calculated for representative chemicals in this category. In addition, readily available measured physicochemical data will be provided for selected product streams in this category.

Biodegradation: Adequate data exist to characterize the aerobic biodegradation potential of the category. No biodegradation testing is planned for this category.

Photodegradation and Hydrolysis: AOP data will be calculated for representative chemicals in this category. In addition, the potential for chemicals in this category to undergo direct photolysis in water will be assessed. A technical discussion on the potential of substances in this category to hydrolyze will be prepared.

Fugacity: Fugacity data will be calculated for representative chemicals in this category.

VI. EVALUATION OF EXISTING ECOTOXICITY DATA AND PROPOSED TESTING

Aquatic endpoints for the HPV Chemical Program include acute toxicity to a freshwater fish and invertebrate, and toxicity to an alga. The product streams of this category are expected to cause a narrow range of toxicity to these species within the range of solubilities acceptable for measuring acute toxicity, which for this category includes those C6 through approximately C10 olefins. This initial assessment is based on existing data for products that can be used to read across to this category and

results of computer modeling using ECOSAR for selected chemical components of product streams in this category [ECOSAR is an aquatic toxicity modeling program and is a subroutine contained in EPIWIN (Ref. 4)]. The relatively narrow range of toxicity for the lower molecular weight members of the category is not unexpected because:

- Constituent chemicals of product streams in this category are neutral organic hydrocarbons whose toxic mode of action is non-polar narcosis and whose potencies are equivalent within the range of solubilities acceptable for measuring acute toxicity, which for this category includes those C6 through approximately C10 olefins.
- Although the bond location is different for alpha olefins and internal olefins, the aquatic toxicities are anticipated to be similar.

The toxic mechanism of short-term toxicity for these types of chemicals is disruption of biological membrane function (Ref. 11), and the differences between measured toxicities (i.e., LC/LL50, EC/EL50) can be explained by the differences between the target tissue-partitioning behavior of the individual chemicals (Ref. 12). The existing fish toxicity database for narcotic chemicals supports a critical body residue (CBR, the internal concentration that causes mortality) of between 4-5 mmol/kg fish (wet weight) (Ref. 13 and 14), and supports the assessment that these chemicals have equal potencies within the range of solubility that results in toxicity. When normalized to lipid content, the CBR is approximately 50 ìmol of hydrocarbon/g of lipid for most organisms (Ref. 15).

The higher olefins addressed in this HPV program are essentially alpha olefins, internal olefins, and mixtures of olefins with varying degrees of branching and carbon chain length. The nature of these materials suggests that: 1) toxicity does not differ with bond location, alpha compared to internal, and 2) branching is not a major factor in toxicity for this class of chemicals. The examples shown in the tables below illustrate this point. EPIWIN was used to estimate product solubility and octanol/water partitioning. The log Kow was used in the EPA ECOSAR toxicity estimation program.

In Table 4, the acute toxicities of fish, *Daphnia* and algae are compared from the ECOSAR estimates. A clear series of increasing acute toxicity with increase in carbon length is observed. Also, the water solubility decreased greatly with increasing carbon chain length. Another set of ECOSAR model predictions for both alpha and internal olefins in Table 5 shows similar toxicity regardless of the nature of the bond location.

Table 4. Mixed Internal Olefins - Acute Toxicity Estimated from ECOSAR

Chemical	**CAS #**	**fish 96h LC50 (mg/L)**	**daphnid 48h LC50 (mg/L)**	**green algae 96h EC50 (mg/L)**	**water solubility (calculated) (mg/L)**	**log Kow (KowWin estimated)**
hexene	25264-93-1	6.16	7.10	4.72	30.32	3.07
heptene	25339-56-4	0.83	1.03	0.73	3.89	4.13
octene	25377-83-7	0.83	1.03	0.73	3.89	4.13

nonene	27215-95-8	0.38	0.48	0.35	1.41	4.55
dodecene	25378-22-7	0.017	0.025	0.020	0.049	6.10
hexadecene	26952-14-7	no CAS # match in ECOSAR				
octadecene	27070-58-2	4.51E-05	7.87E-05	7.38E-05	7.40E-05	9.04

Table 5. Alpha and Internal Olefins - Acute Toxicity Estimated from ECOSAR

Chemical	**CAS #**	**fish 96h LC50 (mg/L)**	**daphnid 48h LC50 (mg/L)**	**green algae 96h EC50 (mg/L)**	**water solubility (calculated) (mg/L)**	**Log Kow (KowWin estimated)**
1-hexene	592-41-6	5.18	6.01	4.01	25.13	3.15
t-2-hexene	4050-45-7	6.16	7.10	4.72	30.32	3.07
t-3-hexene	13269-52-8	6.16	7.10	4.72	30.32	3.07
1-heptene	592-76-7	2.09	2.51	1.73	9.27	3.64
t-2-heptene	14686-13-6	2.49	2.97	2.03	11.19	3.56
t-3-heptene	14686-14-7	2.49	2.97	2.03	11.19	3.56
1-octene	111-66-0	0.83	1.03	0.73	3.35	4.13
t-2-octene	13389-42-9	0.96	1.19	0.84	3.95	4.06
3-octene (E)	14919-01-8	0.96	1.19	0.84	3.95	4.06
t-4-octene	14850-23-8	0.96	1.19	0.84	3.95	4.06
1-decene	872-05-9	0.12	0.16	0.12	1.04	5.12
t-5-decene	7433-56-9	0.14	0.19	0.14	1.21	5.04
1-dodecene	112-41-4	0.017	0.025	0.020	0.049	6.1
1-octadecene	112-88-9	4.51E-05	7.87E-05	7.38E-05	7.40E-05	9.04

A comparison of predictions for 1-, 2-, and 3- hexene for fish, *Daphnia* and algae show similar toxicity within each individual species. This is in part resulting from the partitioning coefficient predictions discussed earlier in the section. The prediction is consistent through 1- and 5- decene with toxicity increasing with carbon chain length and no difference between bond location either internal or in the alpha position. A third point made to confirm toxicity related specifically to partitioning coefficient for narcosis chemicals is shown in Table 6 where the degree of branching is compared for toxicity within a specific olefin and across the series. There is little or no difference in toxicity of the listed olefins when equal carbon number is compared. The three groups shown in Table 6 are predicted to have similar aquatic acute toxicity if carbon numbers are equal. The degree of branching does not have a specific effect.

Table 6. Branched Olefins - Acute Toxicity Estimated from ECOSAR

Chemical	CAS #	fish 96h LC50 (mg/L)	daphnid 48h LC50 (mg/L)	green algae 96h EC50 (mg/L)	water solubility (calculated) (mg/L)	log Kow (KowWin estimated)
2-methyl-1-pentene	763-29-1	4.55	5.30	3.55	21.82	3.21
4-methyl-1-pentene	691-37-2	6.02	6.96	4.63	29.62	3.08
3,3,-dimethyl-1-butene	558-37-2	6.57	7.56	5.02	32.53	3.04
2-methyl-1-hexene	604-02-6	1.84	2.21	1.53	8.06	3.70
2-methyl-1-heptene	15870-10-7	0.73	0.91	0.64	2.91	4.19
2,4,4,-trimethyl-1-pentene	107-39-1	0.92	1.14	0.80	3.77	4.08

Product solubility during toxicity testing is critical to understanding both observations and estimates of effects. For acute toxicity, the existing data (Table 7) indicate that through the C10 olefins, acute toxicity can be observed. Solubility is within the range of observed acute toxicity. For an internal decene stream, the acute toxicity to fish was observed to be 0.12 mg/L and the corresponding estimated solubility using ECOSAR suite is 1.25 mg/L. The effects seen in algae, Daphnia, and fish are approximately equal at water solubility. However, since that value is the LC50, there were concentrations above the LC50 of 0.12 mg/L that may not have been in solution. Above C10, the olefins are insoluble at levels that could cause acute toxicity and data become not usable. The results for tetradecene and higher carbon numbers indicating LC50 > 1000 mg/L only show that there was no toxicity at any exposure concentration. The solubility was too low to have resulted in toxicity. Therefore, meaningful acute toxicity data can be identified below C10 where solubility is high enough to allow the acute effects to be expressed.

Determining the aquatic toxicity of products that have relatively low water solubility and higher vapor pressure, like those in this category, can be difficult because they tend not to remain in solution. These data show that the measured and calculated values are in good agreement through octene, and they also support that the test methods used procedures that were able to maintain exposures.

The testing will include an alga toxicity test (OECD Guideline 201) and a *Daphnia* sp. acute toxicity test (OECD Guideline 202) on a C6 branched (58% branched alkenes) internal olefin to fill the data gaps at the lower end of the homologous series of internal olefins. This material is representative of the low end of the higher olefin category based upon the estimates in Tables 4, 5, and 6. In addition, to clarify the potential for chronic toxicity to aquatic organisms, a *Daphnia magna* Reproduction Test (OECD Guideline 211) will be conducted. Preliminary testing demonstrated that it was not possible to achieve a consistent concentration with a C12 olefin, due to low water solubility. Thus, a C10 alpha olefin was chosen for testing in the chronic toxicity study.

Summary:

The lower homologs of the Higher Olefins Category are sufficiently water soluble to produce acute aquatic toxicity, as has been reported for C6 – C10 alpha and internal olefins. The higher molecular weight olefins, those greater than C10, whose water solubilities are low, are not expected to cause acute aquatic toxicity based on the available data for selected substances. Testing with water accommodated fractions of C14, C16, and C20-24 alpha olefins and C16, C18, and C20-24 internal branched and linear olefins showed no aquatic toxicity in acute tests with fish, invertebrates, and algae. The available data, as shown in Table 7, indicate that water solubility (which is inversely proportional to the length of the alkyl chain), and not the position of the olefinic double bond (alpha or internal) or branching, influences whether a substance will produce acute aquatic toxicity. Acute toxicity tests with *Daphnia magna* and an alga species will be conducted with a C6 branched internal olefin (containing approximately 66% C6 alkenes, 18% C6 alkanes, 1% C7 alkenes, 2% C5 alkenes, 13% C5 alkanes, 58% branched alkenes) to fill the data gaps at the lower end of the homologous series of internal olefins. The testing will include an alga toxicity test (OECD Guideline 201) and a *Daphnia* sp. acute toxicity test (OECD Guideline 202); and, to clarify the potential for chronic toxicity to aquatic organisms, a *Daphnia magna* Reproduction Test (OECD Guideline 211) will be conducted on a C10 alpha olefin.

In addition, the aquatic toxicity of selected olefins will be modeled and the data used to further support the expected acute aquatic toxicity of this category.

VII. TEST PLAN SUMMARY

The following testing, modeling, and technical discussions will be developed for the Higher Olefins Category (Table 10):

- To test the hypothesis, at the lower end of the series, that internalizing the location of the double bond and/or changing the structure from linear to branched does not change the toxicity profile, the HPV battery of tests with a branched internal olefin at the low end of the category (C6 internal olefin stream containing approximately 66% C6 alkenes, 18% C6 alkanes, 1% C7 alkenes, 2% C5 alkenes, 13% C5 alkanes, 58% branched alkenes) will be completed for all mammalian toxicity endpoints and the results compared with available data for 1-hexene. An OECD 422, 28-Day Repeated Dose Rat Oral/Neuro/Reproduction/Developmental Toxicity Screen, will be conducted. Adequate data exist for the other endpoints.

- The location of the double bond and/or changing the structure from linear to branched is not expected to affect the level of aquatic toxicity to a significant degree based on results of modeling (ECOSAR, Ref. 4) for selected lower molecular weight alpha and internal olefins (C6 - 10). To adequately characterize the aquatic toxicity endpoints for the lower molecular weight olefins, two aquatic toxicity studies, the Algal (OECD 201) and Acute Daphnid Toxicity (OECD 202) Tests,

will be conducted with a C6 branched internal olefin stream containing approximately 66% C6 alkenes, 18% C6 alkanes, 1% C7 alkenes, 2% C5 alkenes, 13% C5 alkanes, 58% branched alkenes. In addition, modeling for other selected lower molecular weight olefins will be conducted to support existing data and to fully characterize the algal and acute fish and invertebrate toxicity of this category.

- To test the hypothesis, near the upper end of the series, that changing the location of the double bond or changing the structure from linear to branched does not change the toxicity profile, an OECD 421 Rat Oral Reproduction/Developmental Toxicity Screen will be conducted with a C18 branched and linear internal olefin (32.5% branched) and the results will be compared with data for 1-tetradecene, for which there is available an OECD 422 study, and for C20-24 branched and linear internal olefins, for which there is available an OECD 408 rat 90-day repeated-dose toxicity study. This test will also serve to confirm a lack of reproductive or developmental toxicity in the members near the upper end of the series.

- To clarify the potential for chronic toxicity to aquatic organisms, a *Daphnia magna* Reproduction Test (OECD Guideline 211) will be conducted on a C10 alpha olefin.

- A technical discussion on the potential of representative chemicals in this category to photodegrade will be prepared and atmospheric oxidation potentials for representative chemicals in this category will be calculated.

- A technical discussion on the potential of chemicals in this category to hydrolyze will be prepared.

- Fugacity data for representative chemicals in this category will be calculated.

- Physicochemical data as described in the EPA document titled, *The Use of Structure-Activity Relationships (SAR) in the High Production Volume Chemicals Challenge Program* will be calculated for representative chemicals in this category. In addition, readily available measured physicochemical data will be provided for selected product streams in this category.

If the results from the above testing confirm that the toxicity profiles of all members of the Higher Olefins Category are essentially the same, and/or a pattern from lower to higher carbon numbers exists, then any remaining data gaps can be considered to fall within the ranges defined by the data and no further testing will be warranted. If the results do not confirm that hypothesis, a reassessment of the category will be conducted.

Summaries of results will be developed once the data and analyses are available. This test plan is expected to provide adequate data to characterize the human health effects and environmental fate and effects endpoints for the category under the Program.

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Table 7: Algae Toxicity and Invertebrate and Fish Acute Toxicity of C6-24 Alkenes

Species	Duration	Endpoints (mg/L)	Comments
C6			
Algae			
Selenastrum capricornutum	96-hr EC50 (cell density) 96-hr E_bC50 (biomass) 96-hr E_rC50 (growth rate)	[*study in progress]* (measured)	Alkenes,C6 (internal branched stream). Static; WAF[1]; sealed vessel conditions with no headspace
Selenastrum capricornutum	96-hr EL0	>22	1-hexene >96%. Static; endpoint was biomass; no attempt to prevent evaporation
Invertebrate			
Daphnia magna	48-hr EL50	*[study in progress]* (measured)	Alkenes, C6 (internal branched stream). Static, sealed vessel conditions with minimal headspace
Daphnia magna	48-hr EC50	30 (estimated) ; NOEC =10 mg/L (nominal)	1-hexene 99%. Static, stoppered flask
Vertebrates			
Rainbow trout (*Salmo gairdneri)*	96-hr LC50 96-hr LL50	6.6 (measured) 12.8 (nominal)	Alkenes, C6 (internal branched stream). Mortality, semi-static; no headspace; WAF
Rainbow trout (*Salmo gairdneri)*	24,48,72,96-hr LC50	9.7, 5.6, 5.6 and 5.6	1-hexene >96%. Semi-static, minimal headspace to prevent losses through evaporation
C7 – C9			
Algae	No data		
Invertebrate			
Daphnia magna	48-hr EC50	>3.2<10 (nominal)	1-octene. Static, stirred 4 h before adding test animals; tested in glass-stoppered flask
Daphnia magna	48-hr EC50	>3.2<10 (nominal)	2-octene (trans). Static, stirred 4 h before adding test animals; tested in glass-stoppered flask
Daphnia magna	48-hr EC50	<3.2 (nominal)	1-nonene. Static, stirred 4 h before adding test animals; tested in glass-stoppered flask
Vertebrates			
Rainbow trout (*Salmo gairdneri)*	96-hr LC50 96-hr LL50	0.87 (measured) 8.9 (nominal)	Alkenes, C7-9, C8 rich (internal branched stream). Mortality, semi-static; no headspace; WAF
Zebra fish (*Brachiodanio rerio*)	96-hr LC50	7.5 (nominal)	2-octene (trans). Static, stirred 4 h before adding fish, glass-stoppered flask
Zebra fish (*Brachiodanio rerio*)	24-96-hr LC50	>3.2 <10 (nominal)	1-octene. Static, stirred 4 h before adding fish, glass-stoppered flask
Zebra fish (*Brachiodanio rerio*)	48-hr LC50 96-hr LC50	>3.2 <10 (nominal) <3.2 mg/L (nominal)	1-nonene. Static, stirred 4 h before adding fish, glass-stoppered flask

Species	Duration	Endpoints (mg/L)	Comments
C10 – C13			
Algae			
Selenastrum capricornutum	96-hr EC50 (cell number)	22 (nominal)	C10-13 internal olefin blend (C10 = 6-12%, C11= 27-45%, C12=37-47%, C13=8-17%). Static; concentrations utilized in testing were greater than the water solubility
Selenastrum capricornutum	96-hr EC50	24 (nominal)	C10-13 internal olefin blend (C10 = 6-12%, C11= 27-45%, C12=37-47%, C13=8-17%). Static; concentrations utilized in testing were greater than the water solubility
Scenedesmus subspicatus	72-hr E_bC50	15.4 (nominal)	1-dodecene >97%. Static; reported value exceeds water solubility limit
Invertebrates			
Daphnia magna	48-hr EC50	0.74 (nominal)	C10-13 internal olefin blend (C10 = 6-12%, C11= 27-45%, C12=37-47%, C13=8-17%). Static, vessels not sealed, no headspace
Daphnia magna	48-hr EC50	480 (nominal)	C10-13 internal olefin blend (C10 = 6-12%, C11= 27-45%, C12=37-47%, C13=8-17%). Static, vessels not sealed; concentrations utilized in testing were greater than the water solubility
Vertebrates			
Rainbow trout (*Salmo gairdneri)*	96-hr LC50 96-hr LL50	0.12 (measured) 4.8 (nominal)	Alkenes, C9-11, C10 rich (internal branched stream). Mortality, semi-static; no headspace; WAF; mortality at 0.08 mg/L
Rainbow trout (*Salmo gairdneri)*	96-hr LL0	86.0 (nominal; estimated to be <0.20 [lowest analyzed standard])	Alkenes, C11-13, C12 rich (internal branched stream). Mortality, semi-static; no headspace;WAF; no mortality
Rainbow trout (*Salmo gairdneri)*	96-hr LC50	>1000 (nominal)	C10-13 internal olefin blend (C10 = 6-12%, C11= 27-45%, C12=37-47%, C13=8-17%). Static, vessels not sealed, solution aerated. Concentrations utilized in testing were greater than the water solubility; 2 studies; no mortality in 1 study and 1/10 fish died in the other study
C14			
Algae			
Selenastrum capricornutum	72- 96 hr ELO	1000 (nominal)	1-tetradecene 99%. Growth; static test; WAF; concentration utilized in testing greater than water solubility; no toxicity seen at 1000 mg/L
Invertebrates			
Daphnia magna	24-hr EL0 and 48-hr EL0	1000 (nominal)	1-tetradecene 99%. Immobility; semi-static test; WAF; concentration utilized in testing greater than water solubility; no toxicity seen at 1000 mg/L
Vertebrates			
Rainbow trout (*Salmo gairdneri)*	96-hr LL0	1000 (nominal)	1-tetradecene 99%. Mortality; semi-static test; WAF; concentration utilized in testing greater than water solubility; no toxicity seen at 1000 mg/L
C16 and C18			
Algae			
Selenastrum capricornutum	72-hr EL0	1000 (nominal	1-hexadecene. Growth; static test; WAF; concentration utilized in testing greater than water solubility; no toxicity seen at 1000 mg/l
Selenastrum capricornutum	96-hr EC50	>1000 (nominal)	1-octadecene. Growth; static test; concentrations utilized in testing greater than solubility; no toxicity seen at 1000 mg/l
Invertebrates			

Species	Duration	Endpoints (mg/L)	Comments
Daphnia magna	24-hr EC50 and 48-hr EC50	>1000 (nominal)	1-octadecene. Immobility; static test; concentrations utilized in testing greater than water solubility
Vertebrates			
Rainbow trout (*Salmo gairdneri)*	96-hr LL50	>1000 (nominal)	1-hexadecene. Mortality; semi-static test; WAF; concentrations utilized in testing greater than water solubility; no toxicity seen at 1000 mg/l
Rainbow trout (*Salmo gairdneri)*	96-hr LC0	1000 (nominal)	1-octadecene. Mortality; semi-static test; concentrations utilized in testing greater than solubility; no toxicity seen at 1000 mg/l
Turbot (*Scophthalmus maximus*)	96-hr LL50	>10,000 (nominal)	C16/C18 internal linear and branched blend (50/50). Mortality; semi-static test; concentrations utilized in testing greater than water solubility; no toxicity seen at 10,000 mg/l
C20 – 24			
Algae			
Selenastrum capricornutum	72-hr ELO	1000 (nominal)	C20-24 linear alpha olefin blend. Growth rate, area under the curve; static test; WAF; concentrations utilized in testing greater than solubility; no toxicity seen at 1000 mg/l
Selenastrum capricornutum	72-hr ELO	1000 (nominal)	C20-24 internal linear and branched blend. Growth; static test; WAF; concentrations utilized in testing greater than solubility; no toxicity seen at 1000 mg/l
Invertebrates			
Daphnia magna	48-hr EL0	1000 (nominal)	C20-24 internal linear and branched blend. Immobility; static test; WAF; concentrations utilized in testing greater than solubility; no toxicity seen at 1000 mg/l
Vertebrates			
Rainbow trout (*Oncorhynchus mykiss)*	96-hr LL0	1000 (nominal)	C20-24 linear alpha olefin blend. Mortality; semi-static test; WAF; concentrations utilized in testing greater than solubility; no toxicity seen at 1000 mg/l
Rainbow trout (*Oncorhynchus mykiss)*	96-hr LL0	1000 (nominal)	C20-24 internal linear and branched blend. Mortality; semi-static test; WAF; concentrations utilized in testing greater than solubility; no toxicity seen at 1000 mg/l

1 WAF: Water Accommodated Fractions test procedure was used due to the low water solubility of the test material

Table 8. Existing Data for Higher Olefins

(Robust Summaries for these studies will be submitted separately)

Alpha Olefins															
		Human Health Effects						Ecotoxicity			Environmental Fate				
Chemical Name	**CAS #**	**Acute Toxi-city**	**Genetic Point Mutation**	**Genetic Chrom. Aberr.**	**Sub-chronic**	**Develop -mental**	**Repro-duction**	**Acute Fish**	**Acute Invert.**	**Algal Toxicity**	**Physical Chem.**	**Photo-degra-dation**	**Hydro-lysis**	**Fugacity**	**Biodegra -dation**
1-Hexene	592-41-6 Linear	√	√	√	√	√	√	√	√					√	√
Neohexene	558-37-2 Branched	√	√												
1-Octene	111-66-0 Linear	√	√	√	√			√	√	√				√	
1-Decene	872-05-9 Linear	√	√												√
1-Dodecene	112-41-4 Linear	√	√	√						√[1]					
1-Tetradecene	1120-36-1 Linear	√	√	√	√	√	√	√[2]	√[2]	√[2]				√	√
1-Hexadecene	629-73-2 Linear	√	√	√				√[2]		√[2]					√
1-Octadecene	112-88-9 Linear	√[3]	√	√				√[2]	√[2]	√[2]					√
C12-16 (even numbers)	see C12, 14, 16 above Linear		√	√											
C14-18, C10-14, C12-14, C14-16 (even numbers) (acutes); C13-14 (genetox)	68855-59-4 Linear (C14-18), and individual CAS #s for others	√	√	√											
C20-24 (even numbers)	93924-10-8 Linear	√						√[2]		√[2]					
C22-28 (even numbers)	Various Branched and Linear	√													
C24-54 (even numbers)	131459-42-2 Branched and Linear	√													

√ Adequate existing data available

1 Result questionable because EC50 value is above the water solubility

2 Tested above water solubility

3 C18-C24 and C18-C26 blends (even carbon numbers) were tested

Table 8. Existing Data for Higher Olefins (Continued)

(Robust summaries for these studies will be submitted separately)

Internal Olefins															
		Human Health Effects						Ecotoxicity			Environmental Fate				
Chemical Name	**CAS #**	**Acute Toxicity**	**Genetic Point Mutation**	**Genetic Chrom. Aberr.**	**Sub-chronic**	**Develop-mental**	**Repro-duction**	**Acute Fish**	**Acute Invert.**	**Algal Toxicity**	**Physical Chem.**	**Photo-degra-dation**	**Hydro-lysis**	**Fugacity**	**Biodegra-dation**
Alkenes, C6	68526-52-3 (60-74% branched)		√	√				√							√
Alkenes, C6-8, C7-rich	68526-53-4 (60-74% branched)	√		√											
Alkenes, C7-9, C8-rich	68526-54-5 (60-74% branched)	√						√							√
Alkenes, C8-10, C9-rich	68526-55-6 (60-74% branched)	√	√	√											
Alkenes, C9-11, C10 rich	68526-56-7 (60-74% branched)							√							√
Alkenes, C10-13	85535-87-1	√	√	√											√
Alkenes C11-13, C12-rich	68526-58-9 (60-74% branched)	√						√							√
Tridecene	25377-82-6	√													
Alkenes, C12-14, C13 Rich	68526-58-9 (60-74% branched)														√
C16/C18	Various (20-30% branched)	√[1]			√[2]			√[3,4]							√[3]
C20-24	Various (approx. 70% branched)	√	√	√	√			√[4]	√[4]	√[4]					√
C24-30	Various (approx. 70% branched)	√	√												√

√	Adequate existing data available
1	C16 and C18 tested separately.
2	54% C16, 38% C18, 8% C20, 2% linear alpha, 72% linear internal, 26% branched.
3	50% C16 and 50% C18
4	Tested above water solubility

Table 9: Health Effects of C6-54 Alkenes[1]

	Acute Toxicity	Repeated Dose	Mutagenicity In Vitro	Mutagenicity In Vivo	Repro/Dev
C6	1-hexene and neohexene: Oral: Rat LD50>5.6 g/kg [1-hexene]; >5 g/kg [neohexene] Inhalation: Rat LC50 (4hr) = 32,000 ppm (nom) [1-hexene]; >51,000 ppm [neohexene] Dermal: Rabbit LD50 >2 g/kg [1-hexene]	alkenes, C6 (internal branched stream): Rat oral OECD 422 *[study in progress]* 1-hexene: Rat, 90-day inhalation OECD 413; exposed to 0, 300, 1000, 3000 ppm; NOEL= 1000 ppm (reduced bodyweight [females] and questionable organ weight changes); Rat, 28-day gavage OECD 407; dosed at 0, 10, 101, 1010, 3365 mg/kg/day; NOEL=101 mg/kg/day (kidney effects - males); 1010 mg/kg/day (gastric effects and spleen weight – females) Rat oral OECD 421; dosed at 0, 100, 500, 1000 mg/kg/day; NOEL <100 mg/kg/day for males (kidney effects); 1000 mg/kg/day for females	alkenes, C6 (internal branched stream): *S. typhimurium*, OECD 471, negative with and w/out activation 1-hexene: *S. typhimurium*, OECD 471; Mouse Lymphoma, OECD 476, Mammalian Cell gene mutation ; CHO and Human lymphocytes-Metaphase Chromosome Analysis, OECD 473. All negative with and w/out activation UDS-rat hepatocyte; OECD 482 w/out repeat assay; Negative BALB/3T3 transformation: Negative neohexene: *S. typhimurium*, OECD 471 w/out repeat assay and CHO SCE, OECD 479, negative with and w/out activation	alkenes, C6 (internal branched stream) and 1-hexene: Mouse Bone Marrow micronucleus, OECD 474 (inhln); negative at 0, 1000, 10000 and 25000 ppm [1-hexene] and 1057 ppm [Alkenes, C6] alkenes, C6 (internal branched stream): Mouse Bone Marrow micronucleus, OECD 474 (oral); weakly positive at 5 g/kg	alkenes, C6 (internal branched stream): Rat oral OECD 422; *[study in progress]* 1-hexene: Rat; OECD 421; oral dosed at 0, 100, 500, and 1000 mg/kg/day; NOEL>1000 mg/kg/day (reproductive/developmental toxicity) 1-hexene: Rat; OECD 413; 90-day inhalation exposed to 0, 300, 1000, 3000 ppm; NOEL = 1000 ppm (questionable increases in testes weights)
C7	alkenes, C6-8, C7 rich (internal branched stream): Inhalation: Rat, mouse and guinea pig LC50 (6hr) >42.3 mg/L Dermal: Rabbit LD50 >3160 mg/kg (24 hr)			alkenes, C6-8, C7 rich (internal branched stream): Mouse Bone Marrow micronucleus, EPA OTS 798.5395; (oral); negative at 1.25, 2.5 and 5 g/kg	
C8	1-octene and alkenes, C7-9, C8 rich internal branched stream: Oral: Rat LD50>10g/kg and >5 g/kg [1-octene]; >5g/kg [alkenes, C7-9, C8 rich internal branched stream] Inhalation: Rat LC50 (4 hr) = 8,050 ppm (nom) [1-octene]; rat and mouse LC50 (6 hr) > 31.7 mg/L and guinea pig LC50 (6 hr) < 31.7 mg/L [alkenes, C7-9, C8 rich internal branched stream]	1-octene: Rat, 90 day oral (gavage) dosing at 0, 5, 50 or 500 mg/kg/day; NOEL = 50 mg/kg/day (between 50 and 500, probably only slightly less than 500) (increased kidney weights and decreased plasma chloride in both sexes); LOEL = 500 mg/kg/day	1-octene: *S. typhimurium* Ames Test and BALB/c-3T3 transformation: Negative with and w/out activation Two CHO chromosome abberrations tests; one was negative with and w/out activation and the other had questionable results with activation; (aberration rate increased approx 2-fold over background, but no dose response) and was negative		

	Acute Toxicity	Repeated Dose	Mutagenicity In Vitro	Mutagenicity In Vivo	Repro/Dev
	Dermal: Rabbit LD50 > 1.43 g/kg (24 hr) [1-octene]; >3.16 g/kg (24 hr) [alkenes, C7-9, C8 rich internal branched stream]		w/out activation.		
C9	alkenes, C8-10, C9 rich (internal branched stream): Oral: Rat LD50>2332 mg/kg Inhalation: rat, mice, guinea pig LC50 (6 hr) > 11.1 mg/L Dermal: Rabbit LD50 >2332 mg/kg (24 hr)		alkenes, C8-10, C9 rich (internal branched stream): *S. typhimurium* EPA OTS 798.5265: Negative with and w/out activation	alkenes, C8-10, C9 rich (internal branched stream): Mouse Bone Marrow micronucleus, EPA OTS 798.5395 (oral); negative at doses of 1.25, 2.5 and 5 g/kg	
C10	1-decene: Oral: Rat LD50>10g/kg Inhalation: Rat LC50 >saturation conc. for 1 and 4 hr exposures at saturation of 9.3 and 8.7 mg/L Dermal: Rabbit LD50 >10 g/kg (24 hr)		1-decene: *S. typhimurium*; OECD 471; Negative with and w/out activation		
C10-13	C10-13 internal olefins: Oral: Rat LD50>7.74g/kg Inhalation: Rat LC50 >2.1 mg/L (saturation conc.) for 4 hr exposure Dermal: Rat LD50 >3080 mg/kg (24 hr) C13 internal olefin: Oral: LD50>5 g/kg Dermal: Rat LD50 > 2 g/kg		C10-13 internal olefins: *S. typhimurium and E. Coli* Ames Test; Negative with and w/out activation Chromosome aberration test with rat liver RL1 cells: Negative		
C12	1-dodecene; C12, 14, 16 linear AO blend; and alkenes, C11-13, C12 rich: Oral: Rat LD50 >10g/kg [1-dodecene]; >7.74 g/kg [alkenes, C11-13, C12 rich internal branched stream] Inhalation: Rat LC50 (1hr) >9.9 mg/L [C12, 14, 16 linear AO blend]; rat, mouse and guinea pig LC50 (6 hr) > 4.4 mg/L [alkenes, C11-13, C12 rich internal branched stream]	C12, 14, 16 linear AO blend: Dermal: rat; 9 applications (6 hr) over 2 wk period of 1 or 2 g/kg/day; severe irritation and decrease in body and organ weights seen with 2 g/kg; slight irritation seen with 1 g/kg; NOAEL (systemic) = 1 g/kg/day	1-dodecene; C12, 14, 16 linear AO Blend; and C11-12 AO blend: *S. typhimurium* and *E.coli* Ames Test [1-dodecene]; CHO/HGPRT [C12, C14, C16 linear AO blend]; *S. cerevisiae* Mitotic Gene conversion Assay [C11-12 AO blend]: All negative with and w/out activation Chromosome aberration test with rat liver RL1 cells [1-dodecene];	C12, 14, 16 linear AO blend: Mouse Micronucleus Bone Marrow Test (dermal); No remarkable clinical findings-negative at doses of 1000, 2500 and 5000 mg/kg for 2 days	

	Acute Toxicity	Repeated Dose	Mutagenicity In Vitro	Mutagenicity In Vivo	Repro/Dev
	Dermal: Rabbit LD50 > 10 g/kg (24 hr)[C12-16 AO blend] and rat >10 g/kg (24 hr)[1-dodecene]; rabbit LD50 >2446 mg/kg (24 hr) [alkenes, C11-13, C12 rich internal branched stream]		BALB/3T3 Mouse embryo transformation and UDS [C12, 14, 16 linear AO blend]: All negative		
C14	Various blends: Oral: Rat LD50 17.3 g/kg [C10-14 AO] and >10g/kg [C12-14, C14-18, C14-16 AO]; Mouse LD50= 21.3 g/kg [C10-14 AO] Inhalation: Rat LC50 (1hr) = 9900 mg/m^3 [C12, 14, 16 linear AO blend]; Mouse LC50 = 223 mg/L [C10-14 AO blend] Dermal: Rat LD50 >10 g/kg [C12, 14, 16 linear AO blend; C12-14 AO blend; C14-18 AO blend, and C14-16 AO blend]	1-tetradecene: Combined OECD 422; rat; gavage dosed at 0, 100, 500 or 1000 mg/kg/day for up to 51 days. NOEL = 100 mg/kg/day for females(liver effects); no NOEL for males due to kidney effects	C13-14 AO blend: *S. typhimurium*, *S. cervisiae* Mitotic recombination with and w/out activation; CA Rat Liver RL1 cells: Negative		1-tetradecene: Rat; Modified OECD 422; gavage at 0, 100, 500 or 1000 mg/kg/day for up to 51 days; NOAEL (reproductive and developmental toxicity) = 1000 mg/kg/day
C16	1-hexadecene and C16 internal linear and branched: Oral: Rat LD50 >10g/kg [1-hexadecene] and >5050 mg/kg [C16 internal linear and branched] Inhalation: Rat LC50 = 6.4 mg/l (4hr) and >8.5 mg/l (1 hr) [1-hexadecene] Dermal: Rabbit LD50 >2020 mg/kg (24 hr) [C16 internal linear and branched]	C16/18 internal linear and branched: Oral: OECD 407; rat; dosed at 0, 25, 150 or 1000 mg/kg/day for up to 4 wks. NOAEL = 1000 mg/kg/day C12, 14, 16 linear AO blend: Dermal: Rat; 9 applications (6 hr) over 2 wk period of 1 or 2 g/kg/day; severe irritation and decrease in bodyand organ weights seen with 2 g/kg/day; slight irritation seen with 1 g/kg; NOAEL (systemic) = 1 g/kg/day 1-hexadecene: Dermal: guinea pig; 4 exposures in 8 days; max. score of 8/8; severely irritating (only limited information on conditions used)	1-hexadecene: OECD 471, *S. typhimurium*: Negative with and w/out activation C12, 14, 16 linear AO blend: UDS (rat hepatocyte), CHO HGPRT and BALB/3T3 transformation: Negative	1-hexadecene: OECD 474, Mouse Micronucleus Assay (oral); Negative at 7.85 g/kg (only dose administered). C12, 14, 16 linear AO blend: Mouse Micronucleus Assay (dermal); Negative at doses of 1000, 2500 and 5000 mg/kg for 2 days.	C16/18 internal linear and branched: Oral: OECD 407; rat; dosed at 0, 25, 150 or 1000 mg/kg/day for up to 4 wks; NOAEL for reproductive effects from limited data (effect on reproductive organs) = 1000 mg/kg/day
C18	various AO blends and C18 internal linear and branched: Oral: Rat LD50 >10g/kg [C14-18 AO blend, C18-26 AO blend, C18-24 AO blend] and >5050 mg/kg [C18 internal linear and branched]	C18 internal linear and branched: Oral: OECD 421 (limited general toxicity endpoints); rats *[study in progress]* C16/18 internal linear and branched:	1-octadecene: *S. cervisiae* Mitotic gene conversion and *S. typhimurium* and *E. coli* Ames Test with and w/out activation; Chromosome aberration test with Rat Liver RL1 cells: Negative		C18 internal linear and branched: Oral: OECD 421; rat; *[study in progress]* C16/18 internal linear and branched: Oral: OECD 407; rat; dosed at 0, 25, 150 or 1000 mg/kg/day for up

	Acute Toxicity	**Repeated Dose**	**Mutagenicity In Vitro**	**Mutagenicity In Vivo**	**Repro/Dev**
	Inhalation: Rat LC50 > saturated vapor concentration (1 and 4 hr) [C16/C18 AO] Dermal: Rabbit LD50 >10 g/kg (24 hr) [C18-24 AO blend, C18-26 AO blend] and >2020 mg/kg (24 hr) [C18 internal linear and branched]	Oral: OECD 407; rat; dosed at 0, 25, 150 or 1000 mg/kg/day for up to 4 wks. NOAEL = 1000 mg/kg/day			25, 150 or 1000 mg/kg/day for up to 4 wks; NOAEL for reproductive effects from limited data (effect on reproductive organs) = 1000 mg/kg/day
C20-24	C20-24 and C22-28 linear AO and C20-24 internal linear and branched: Oral: Rat LD50 >5 g/kg [C20-24 and C22-28 linear AO, C20-24 internal linear and branched] and >15 g/kg [C20-24 linear AO] Dermal: rat LD50 >5 ml/kg (24 hr) [C20-24 linear AO] and >2 g/kg [C20-24 internal linear and branched]	C20-24 internal linear and branched: OECD 408; rat gavage dosed at 0, 100, 500 or 1000 mg/kg/day for 90 days with 4-wk recovery group. NOAEL = 1000 mg/kg/day; NOEL = 100 mg/k/day for males (glucose); NOEL = 500 mg/kg/day for females (liver weight and adrenal hypertrophy)	C20-24 internal linear and branched: *S. typhimurium* and *E. coli* OECD 471; and OECD 473 Chromosome aberrations test with human lymphocytes: Negative with and w/out activation	C20-24 internal linear and branched: OECD 474 Mouse Micronucleus Assay (i.p.): Negative at doses of 500, 1000 and 2000 mg/kg/day	C20-24 internal linear and branched: Oral: OECD 408; rat; dosed at 0, 100, 500 or 1000 mg/kg/day for 90 days with a 4-wk recovery group; NOEL for reproductive effects from limited data (effect on reproductive organs) = 1000 mg/kg/day
C24-28	C24-30 internal linear and branched: Oral: Rat LD50 >5 g/kg		C24-30 internal linear and branched: *S. typhimurium* OECD 471: Negative with and w/out activation		
C24-54 (C30+)	C24-54(C30+) AO linear and branched: Oral: Rat LD50 >2 g/kg and >15 g/kg Dermal: rat LD50 >5 ml/kg (24 hr)				

1 Study details and references are found in the robust summaries in the dossiers.

Table 10. Assessment Plan for Higher Olefins Category Under the Program
(Robust summaries for existing studies will be submitted separately.)

Alpha Olefins															
		Human Health Effects						Ecotoxicity			Environmental Fate				
Chemical	CAS #	Acute Toxicity	Genetic Point Mut.	Genetic Chrom.	Sub-chronic	Develop-mental	Reproduc-tion	Acute Fish	Acute Invert.	Algal Toxicity	Physical Chem.	Photo-deg.	Hydro-lysis	Fugacity	Biodeg.
1-Hexene (SIDS)	592-41-6 Linear	Ö	Ö	Ö	Ö	Ö	Ö	Ö	Ö	Ö					Ö
Neohexene	558-37-2 Branched	Ö	Ö	Ö	RA	RA	RA	RA	RA	RA	SAR	TD	TD	CM	RA
1-Tetradecene **(SIDS)**	1120-36-1 Linear	Ö	Ö	Ö	Ö	Ö	Ö	Ö	Ö	Ö				Ö	Ö
1-Tridecene	2437-56-1 Linear	RA	RA	RA	RA	RA	RA	RA	RA	RA	SAR	TD	TD	CM	RA
1-Hexadecene **(ICCA)**	629-73-2 Linear	Ö	Ö	Ö	RA	RA	RA	Ö	RA	Ö	SAR	TD	TD	CM	Ö
1-Octadecene **(ICCA)**	112-88-9 Linear	Ö	Ö	Ö	RA	RA	RA	Ö	Ö	Ö	SAR	TD	TD	CM	Ö
Alkenes, C10-16 alpha (even carbon numbers)	68855-58-3 Linear	RA	RA	RA	RA	RA	RA	RA	RA	RA	SAR	TD	TD	CM	RA
Alkenes, C14-18 alpha (even carbon numbers)	68855-59-4 Linear	Ö	RA	RA	RA	RA	RA	RA	RA	RA	SAR	TD	TD	CM	RA
Alkenes, C14-20 alpha (even carbon numbers)	68855-60-7 Linear	RA	RA	RA	RA	RA	RA	RA	RA	RA	SAR	TD	TD	CM	RA
1-Eicosene	3452-07-1 Linear	RA	RA	RA	RA	RA	RA	RA	RA	RA	SAR	TD	TD	CM	RA
1-Docosene	1599-67-3 Linear	RA	RA	RA	RA	RA	RA	RA	RA	RA	SAR	TD	TD	CM	RA
1-Tetracosene	10192-32-2 Linear	RA	RA	RA	RA	RA	RA	RA	RA	RA	SAR	TD	TD	CM	RA
a-olefin fraction C20-24 cut (even numbers)	93924-10-8 Linear	Ö	RA	RA	RA	RA	RA	Ö	RA	Ö	SAR	TD	TD	CM	RA
a-olefin fraction C24-28 cut (even carbon numbers)	93924-11-9 Branched and Linear	RA	RA	RA	RA	RA	RA	RA	RA	RA	SAR	TD	TD	CM	RA
alkene, C24-54 branched and linear, alpha (even numbers)	131459-42-2 Branched and Linear	Ö	RA	RA	RA	RA	RA	RA	RA	RA	SAR	TD	TD	CM	RA

Ö Adequate existing data available TD Technical discussion proposed RA Read Across (see Sec. IV & VI)

CM Computer Modeling proposed SAR Structure Activity Relationship (plus measured values where available) T Proposed Testing

Table 10. Assessment Plan for Higher Olefins Category Under the Program (Continued)

(Robust summaries for existing studies will be submitted separately.)

Internal Olefins															
		Human Health Effects						Ecotoxicity			Environmental Fate				
Chemical	CAS #	Acute Toxicity	Genetic Point Mut.	Genetic Chrom.	Sub-chronic	Develop-mental	Reproduc-tion	Acute Fish	Acute Invert.	Algal Toxicity	Physical Chem.	Photo-deg.	Hydro-lysis	Fugacity	Biodeg.
Alkenes, C6	68526-52-3 Br. and Lin.	RA	Ö	Ö	T	T	T	Ö	T	T	SAR	TD	TD	CM	Ö
Hexene **(ICCA)**	25264-93-1 Linear	RA	RA	RA	RA	RA	RA	RA	RA	RA	SAR	TD	TD	CM	RA
Alkenes, C6-8, C7 rich	68526-53-4 Br. and Lin.	Ö	RA	Ö	RA	RA	RA	RA	RA	RA	SAR	TD	TD	CM	RA
Heptene **(ICCA)**	25339-56-4 Linear	RA	RA	RA	RA	RA	RA	RA	RA	RA	SAR	TD	TD	CM	RA
Octene **(ICCA)**	25377-83-7 Linear	RA	RA	RA	RA	RA	RA	RA	RA	RA	SAR	TD	TD	CM	RA
Alkenes, C7-9, C8-rich	68526-54-5 Linear or Br. and Lin.	Ö	RA	RA	RA	RA	RA	Ö	RA	RA	SAR	TD	TD	CM	Ö
Nonene **(ICCA)**	27215-95-8 Linear	RA	RA	RA	RA	RA	RA	RA	RA	RA	SAR	TD	TD	CM	RA
Alkenes, C8-10, C9-rich	68526-55-6 Linear or Br. and Lin.	Ö	Ö	Ö	RA	RA	RA	RA	RA	RA	SAR	TD	TD	CM	RA
Alkenes, C9-11, C10-rich	68526-56-7 Linear or Br. and Lin.	RA	RA	RA	RA	RA	RA	Ö	RA	RA	SAR	TD	TD	CM	Ö
C10,12 Olefin rich hydrocarbons	68514-32-9 Linear	RA	RA	RA	RA	RA	RA	RA	RA	RA	SAR	TD	TD	CM	RA
Alkenes, C10-12, C11-rich	68526-57-8 Br. and Lin.	RA	RA	RA	RA	RA	RA	RA	RA	RA	SAR	TD	TD	CM	RA

Ö Adequate existing data available TD Technical discussion proposed RA Read Across (see Sec. IV & VI)
CM Computer Modeling proposed SAR Structure Activity Relationship T Proposed Testing

(plus measured values where available)

Table 10. Assessment Plan for Higher Olefins Category Under the Program (Continued)
(Robust summaries for existing studies will be submitted separately.)

Internal Olefins (continued)															
		Human Health Effects						Ecotoxicity			Environmental Fate				
Chemical	CAS #	Acute Toxicity	Genetic Point Mut.	Genetic Chrom.	Sub-chronic	Develop-mental	Reproduc-tion	Acute Fish	Acute Invert.	Algal Toxicity	Physical Chem.	Photo-deg.	Hydro-lysis	Fugacity	Biodeg.
Alkenes, C11-13, C12-rich	68526-58-9 Linear or Branched or Br. and Lin.	Ö	RA	RA	RA	RA	RA	Ö	RA	RA	SAR	TD	TD	CM	Ö
Dodecene (**ICCA; not sponsored in HPV)**	25378-22-7 Linear	RA	RA	RA	RA	RA	RA	RA	RA	RA	SAR	TD	TD	CM	RA
Heavy polymerization naphtha (petroleum)	68783-10-8 Branched	RA	RA	RA	RA	RA	RA	RA	RA	RA	SAR	TD	TD	CM	RA
C12,14 Olefin rich hydrocarbons	68514-33-0 Linear	RA	RA	RA	RA	RA	RA	RA	RA	RA	SAR	TD	TD	CM	RA
Alkenes, C10-16	68855-58-3 Linear	RA	RA	RA	RA	RA	RA	RA	RA	RA	SAR	TD	TD	CM	RA
Alkenes, C15-C18	93762-80-2 Linear	RA	RA	RA	RA	RA	RA	Ö	Ö	Ö	SAR	TD	TD	CM	RA
Octadecene (Not HPV and not sponsored under HPV; data used to support category)	Various Branched and Linear	Ö			Ö	T	T	Ö	Ö	Ö					Ö
C20-24 (Not HPV and not sponsored under HPV; data used to support category)	Various Branched and Linear	Ö	Ö	Ö	Ö			Ö	Ö	Ö					Ö

Ö Adequate existing data available
CM Computer Modeling proposed
TD Technical discussion proposed
SAR Structure Activity Relationship (plus measured values where available)
RA Read Across (see Sec. IV & VI)
T Proposed Testing