HIGH PRODUCTION VOLUME (HPV)

CHEMICAL CHALLENGE PROGRAM

TEST PLAN

For the

POLYPHENYL (3- & 4-PHENYL RINGS) CATEGORY

CAS Number 26140-60-3; Terphenyls, Mixed

CAS Number 29036-02-0; Quaterphenyls

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EXECUTIVE SUMMARY

Solutia Inc. voluntarily submits the following Category Justification, Screening Information Data (Robust Summaries) and Test Plan for review under the Environmental Protection Agency's High Production Volume (HPV) Chemicals Challenge Program. The Category, entitled "Polyphenyls (3- & 4-Phenyl Rings)" consists of two members, Terphenyls, Mixed (CAS No. 26140-60-3), and Quaterphenyls (CAS No. 29036-02-0), each consisting of multiple isomers. This Category is justified on the basis of chemical structure similarity, as well as similarity of basic screening data, as provided in an initial assessment of physico-chemical properties, environmental fate and human and environmental effects.

A substantial amount of data exists to evaluate the potential hazards associated with this Category of chemicals. Use of key studies available from data already developed, derived from recommended estimation models, or use of "read-across" methods collectively provide adequate support to characterize most Endpoints in the HPV Chemicals Challenge Program. Some additional testing is recommended to complete the assessment of members within this Category.

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TEST PLAN FOR POLYPHENYLS (3- & 4-Phenyl Rings)

I. INTRODUCTION AND IDENTIFICATION OF CATEGORY MEMBERS

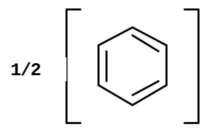
Under EPA's High Production Volume (HPV) Chemicals Challenge Program, Solutia Inc. has committed to voluntarily compile basic screening data on two members from the same structural family of aromatic hydrocarbons, namely Terphenyls, Mixed (CAS no. 26140-60-3) and Quaterphenyls (CAS no. 29036-02-0). Solutia Inc. believes that a Category of Polyphenyls (3- & 4-Phenyl Rings) is appropriate for this review and is scientifically justifiable. While the HPV process is based on specific chemicals as identified by CAS number, the members nominated for this Category are, in actuality, mixtures of 3- and 4-phenyl ring structures, respectfully. Further, the products tested for each Category member contain some 3-ring moieties and some 4-ring components; however, each product test article is predominated by isomeric forms synonymous with their chemical name, i.e. Terphenyls, Mixed contains a preponderance of m-terphenyl, p-terphenyl and o-terphenyl isomers with small amounts of quaterphenyls while Quaterphenyls contains a high percentage of 4-phenyl ring quaterphenyls with small amounts of 3-ring terphenyls.

The data included in this Category involve physicochemical properties, environmental fate, and human and environmental effects of the two members for which Solutia has volunteered in this Category, as defined by the Organization for Economic Cooperation and Development (OECD). However, as each member is a mixture we have also provided available data on the major components (ortho-, meta- and para-) of Mixed Terphenyl isomers as surrogates in our data assessment program. No information has been located on isolated Quaterphenyl isomers. Individual Robust Summaries have been assembled for each referenced Terphenyl component, as well as each of the two Category members nominated.

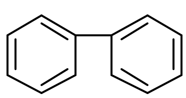
The information provided comes from existing data found in the scientific literature or developed on behalf of Solutia Inc., or its predecessor Monsanto Co. or from recommended estimation models. This submission fulfills Solutia's initial obligation to the HPV Challenge Program for these two chemicals.

A. Structure and Nomenclature

The members of this family of Polyphenyls (3- & 4-phenyl rings) include the following chemicals:

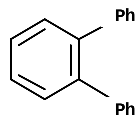


a. Terphenyls, Mixed-
CAS No. 26140-60-3
CA Index Name**:** Terphenyl (8CI, 9CI)
Synonyms: Benzene, diphenyl-; Benzene, [biphenyl]yl-; Diphenylbenzene; Terbenzene; Triphenyl; Santowax R; Therminol 88; Santowax CST; Therminol 75; MCS-1980; Santowax MP; Santowax OM; CP 75052

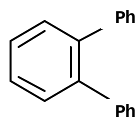


b. Quaterphenyls
CAS No. 29036-02-0
CA Index Name: Quaterphenyl (7CI, 9CI)
Synonyms: Quaterbenzene; Santotar 9; Santowax Q

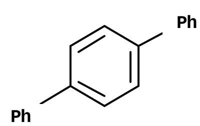
The following Surrogate Chemicals have been used as an aid in this assessment to evaluate the Mixed Terphenyl group, as they are primary components of that substance.



c. ortho-Terphenyl
CAS No. 100-00-5
CA Index Name: 1,1':2',1"-Terphenyl (9CI)
Synonyms: o-Terphenyl (8CI); 1,1'-Biphenyl, 2-phenyl-; 1,2-Diphenylbenzene



d. meta-Terphenyl
CAS No. 92-06-8
CA Index Name: 1,1':3',1"-Terphenyl (9CI)
Synonyms: m-Terphenyl (8CI); 1,1'-Biphenyl, 3-phenyl-; 1,3-Diphenylbenzene; 1,3-Terphenyl; 3-Phenyl-1,1'-biphenyl; m-Diphenylbenzene; m-Triphenyl;



e. para-Terphenyl
CAS No. 92-94-4
CA Index Name: 1,1':4',1"-Terphenyl (9CI)
Synonyms: p-Terphenyl (8CI); 1,1'-Biphenyl, 4-phenyl-; 1,4-Diphenylbenzene; 4-Phenylbiphenyl; p-Diphenylbenzene; p-Triphenyl;

B. Manufacturing & Use

Members of the Polyphenyl (3- & 4-Phenyl Rings) Category, Mixed Terphenyls and Quaterphenyls are products originating from the same chemical manufacturing process. A polyphenyl stream consisting primarily of four or less aromatic rings is manufactured at a single US manufacturing site in an essentially closed, continuous process. This polyphenyl stream is processed through varying degrees of physical separation into commercial products which are either sold directly or used as site limited intermediates for further chemical reaction to manufacture other products. Nowhere in the process are 100 % mixed terphenyls or 100 % quaterphenyls isolated. All products manufactured and used as test articles for the studies described in this Test Plan, are combinations of terphenyls and quaterphenyls. Solutia does not isolate nor sell any of the individual terphenyl isomers (ortho-, meta- or para-) or any of the individual Quaterphenyl isomers in other than small volume, research or product development quantities.

Solutia Inc. historically has marketed three products from this singular process. One product, sold under the tradenames SANTOWAX R ® and THERMINOL 88 ® contains a high (81:17) Mixed Terphenyl:Quaterphenyl ratio. A second product, sold as THERMINOL 75® (also known as MCS-1980 during earlier product development) possesses a lower (62:34) Terphenyls:Quaterphenyl ratio, although Mixed Terphenyls are still the predominant chemical species. Both Mixed Terphenyl products are predominantly mixtures of meta- and para-terphenyl isomers, with only very small amounts (< 10%) of the ortho- isomer present. A third product, sold as SANTOTAR 9 ® or SANTOWAX Q ® consists primarily (90% Quaterphenyls: 10% Terphenyls) of Quaterphenyls.

A TLV ® of 5.0 mg/m^3 (ceiling) has been established for Terphenyls (ACGIH, 2002) in order to protect against possible ocular, dermal, and respiratory tract irritation; human responses to terphenyls have been characterized as “relatively low” with no adverse effects detected in a work force except irritation (Beard and Noe, 1982). Only a few employees are involved in the manufacturing operation and have minimal potential for skin or airborne exposure, which occurs chiefly during material transfer operations. Specific manufacturing procedures and practices have been established to minimize occupational exposure potential, especially as these materials are handled under high temperature conditions which could cause thermal burns.

While individual terphenyl isomers have reportedly been used as solvents or even consumer products, no such uses are known to pertain to the mixed isomer products currently sold by Solutia. Essentially all of Solutia’s current commercial products containing Mixed Terphenyls and Quaterphenyls are used as heat storage and transfer agents in closed systems in the industrial setting. Loss to the atmosphere or from non-POTW aqueous streams during manufacturing or processing is minimal and only by accident. Hence, very limited occupational or environmental exposure is expected to occur.

II. CATEGORY JUSTIFICATION

For purposes of the HPV Challenge Program, EPA has provided guidance as to the definition and justifications to be used in selection of a chemical Category (US EPA, 1999c). The definition states that a chemical Category should be "a group of chemicals whose physicochemical and toxicological properties are likely to be similar or follow a regular pattern as a result of structural similarity". Solutia Inc. has opted to form the Polyphenyl (3- & 4-Phenyl Rings) Category with this guidance in mind.

Common Structure

Each of the two chemical substances selected for inclusion in this category is a mixture of aromatic hydrocarbons containing 3 and 4 benzene rings, respectively. The products formed during manufacturing are separate streams originating from the same manufacturing process. Each product which served as a test article in the data presented in this Test Plan is one of mixed chemicals containing varying amounts of differing isomeric forms of the two base chemicals: terphenyls (polyphenyls with 3 open phenyl rings) and quaterphenyls (polyphenyls with 4 open phenyl rings). The difference between the Mixed Terphenyls streams and the Quaterphenyls stream lies in the amount of isomeric forms of the terphenyl components versus the amount and isomeric forms of quaterphenyls found within each substance. Mixed Terphenyls contain higher levels of 3-ring moieties (generally in the 60-90% range) and lesser 4-ring structures (10-30%) while other Quaterphenyls contain high levels (80-90%) of 4-ring structures and lower (10-20%) levels of 3-ring moieties. Throughout this Test Plan the terms "Mixed Terphenyls" and "Quaterphenyls" will refer to these commercial mixtures rather than to the chemicals as described by the specific CAS numbers (unless otherwise noted). Hence, both entities within this Category are of common structure.

Common Functional Groups

Each of these Polyphenyls are aromatic hydrocarbons containing a mixture of either 3 or 4 noncondensed benzene rings without any additional functional constituents added. The position (either *ortho* to, *meta* to, or *para* to each other) of the ring placement of the secondary or tertiary benzene rings is the only structural difference between the various isomers.

Similar or even Identical Properties or Hazards

While there are substantive differences in the physicochemical properties of the individual terphenyl and quaterphenyl isomers, the mixed isomeric forms are less distinctive. Their physical form ranges from crumbly, partially waxy-like to completely waxy at room temperature. Increased molecular weights of the 4-phenyl ring quaterphenyls renders greater waxiness, lower volatility and higher boiling points. Other parameters are similar, but not identical. A summary of available physicochemical data can be found in Table 3.

Environmental Fate data are summarized in Table 4. Whether measured or estimated, there appears close agreement in each of the HPV Endpoints recorded for members of this Category, as they all possess qualities reflective of their condensed ring structures.

Comparative aquatic toxicity of the members of this Category can be found in Table 5. As shown, a similar degree of toxicity has been observed across the multiple test species included in this dataset.

Table 6 summarizes the comparative mammalian toxicity of these chemicals. Comparative review indicates a similar degree of toxicity between both Category members for all endpoints.

Thus, similarities in the degree of toxicity and the extensive comparative data sets presented for the Mixed Terphenyls and the Quaterphenyls support use of a Category approach for these chemicals.

III. TEST PLAN RATIONALE

The information obtained and included to support this Test Plan has come from either 1) internal studies conducted by/or for Solutia Inc. (or its predecessor Monsanto Co.), 2) has been extracted from the scientific literature either as primary references or as found in well-accepted, peer-reviewed reference books, or 3) were estimated using environmental models accepted by the US EPA (1999b) for such purposes. This initial assessment includes information on physicochemical properties, environmental fate, and human and environmental effects associated with each of the two Mixed Terphenyls products sold by Solutia as well as the commercial Quaterphenyls product of this Category. The data used to support this program include those Endpoints identified by the US EPA (1998); key studies have been identified for each Endpoint and summarized in Robust Summary form and included in Section VII of this dossier. Thus, we have consolidated test results from both Mixed Terphenyl products into one Robust Summary and have generated a second Robust Summary to include data on Quaterphenyls. As these substances are, themselves, mixtures of isomeric forms, we have chosen to develop separate Robust Summary data packages for each of the three Terphenyl isomers (ortho, meta, and para) as Surrogates. Information available on these Surrogates has been used as Supplemental to support existing data needs through "read across" or further corroborate data developed on Mixed Terphenyls.

All Environmental, Ecotoxicity and Mammalian Toxicity studies were reviewed and assessed for reliability according to standards specified by Klimisch *et al* (1997), as recommended by the US EPA (1999a). The following criteria were used for codification:

1. Reliable without Restriction - Includes studies which comply with US EPA and/or OECD-accepted testing guidelines, which were conducted using Good Laboratory Practices (GLPs) and for which test parameters are complete and well documented,

2. Reliable with Restriction – Includes studies which were conducted according to national/international testing guidance and are well documented. May include studies conducted prior to establishment of testing standards or GLPs but meet the test parameters and data documentation of subsequent guidance; also includes studies with test parameters which are well documented and scientifically valid but vary slightly from current testing guidance. Also included were physical-chemical property data obtained from reference handbooks as well as environmental endpoint values obtained from an accepted method of estimation (i.e. EPIWIN).

3. Not Reliable – Includes studies in which there are interferences in either the study design or results that provide scientific uncertainty or where documentation is insufficient.

4. Not Assignable – This designation is used in this dossier for studies which appear scientifically valid but for which insufficient information is available to adequately judge robustness.

Those studies receiving a Klimisch rating of 1 or 2 are considered adequate to support data assessment needs in this Dossier. Those key studies selected for inclusion are considered typical of the Endpoint responses observed in other studies of a similar nature and design, which were identified during our search of the literature.

IV. TEST PLAN SUMMARIES AND CONCLUSIONS

The referenced available data for each Category member has been placed in an Endpoint-specific matrix and summarized individually in Table 1 (Mixed Terphenyls) and Table 2 (Quaterphenyls). Generally, data exists for each Category Member to evaluate its potential hazards in this screening level assessment. Where an HPV Endpoint has been identified as untested, the need for testing has been assessed (1) with the understanding that these chemicals behave in a similar and/or predictable manner, and (2) by interpolation (i.e. Read-Across technique) between data from other key studies already available either with the mixture or from a Surrogate. Thus, we have used preexisting data, where possible, to support our assessment of potential hazards of the chemicals in this Category and avoid the unnecessary testing of additional laboratory animals.

Conclusion: Nearly all HPV Endpoints have been satisfied for the Mixed Terphenyls and Quaterphenyls with data from studies that were either well

documented, used OECD guideline methods and conducted in accord with GLPs, or were estimated from acceptable estimation modeling programs. Use of the "Read Across" technique was employed to support a limited number of Quaterphenyl Endpoints. No HPV Endpoint data was identified for assessment of the Reproductive Toxicity for either Category member. Hence, a single Reproductive Toxicity Screen (OECD 421) is proposed with Mixed Terphenyls. The use of the "read across" technique to assess Quaterphenyls for this Endpoint is planned, to avoid the unnecessary testing of animals.

Physical-chemical property values - Physicochemical values for nearly all Endpoints were obtained for commercially available Mixed Terphenyls and Quaterphenyls. Thus, these values were given a classification of "2-Reliable with restrictions". Where no values were found, estimates have been made for Mixed Terphenyls and Quaterphenyls from accepted models. Use of these models to estimate other physico-chemical properties provided good concordance with known values for individual Mixed Terphenyls isomers. Thus, they have been given a classification of "2-Reliable with restrictions".

Environmental Fate values describing Transport (Fugacity) and Photodegradation for Mixed Terphenyls and Quaterphenyls were obtained using a computer estimation –modeling program (EPIWIN, 2002) recommended by EPA and classified as "2-Reliable with restrictions". Biodegradation data for each of the Category members were characterized in well documented studies and conducted in a design similar to OECD test #302 guidance. These studies thus are classified as "2-Reliable with restrictions". No Stability in Water (hydrolysis) data were found for either Mixed Terphenyls or Quaterphenyls. Based on their chemical structure, it can be reasonably expected that both Mixed Terphenyls and Quaterphenyls are resistant to hydrolysis; thus, additional testing is unwarranted.

Ecotoxicity – Acute Fish, Invertebrate and Plant (Algal) Toxicity Endpoints for Mixed Terphenyls have been fulfilled with studies that were conducted according to US EPA test guidance consistent with OECD test guidelines. All studies were well documented and were designated "2-Reliable with restrictions". An Acute Invertebrate Toxicity study, also designated as "2-Reliable with restrictions" has been included for Quaterphenyls. The Acute Fish and Algal Toxicity Endpoints for Quaterphenyls are fulfilled using the 'Read Across" method of data evaluation to that developed for Mixed Terphenyls, as no fully reliable studies were found in these two areas. Utility of this methodology is strengthened by comparative use of estimation modeling data for Mixed Terphenyls and individual Terphenyl isomers.

Mammalian Toxicity Endpoints, including Acute Toxicity, Repeated Dose Toxicity, Ames Mutagenicity and Chromosomal Aberration Testing for Mixed Terphenyls have been fulfilled by way of tests that either conformed directly to OECD test guidance or followed test designs sufficient to assess toxicity. Thus, they have been designated either “1-Reliable without restriction” or “2-Reliable with restrictions”.

An adequately conducted (“2-Reliable with restrictions”) Acute Toxicity study has been conducted with Quaterphenyls from which a similar order of toxicity is observed as seen with Mixed Terphenyls. No Ames or Cytogenetics Mutagenicity studies or Repeated Dose Toxicity were identified for Quaterphenyls. However, based on structural similarity and composition of Mixed Terphenyls tested for these endpoints, these Endpoints for Quaterphenyls have been filled using the “Read Across” technique for data assessment.

No adequately conducted study has been identified to assess reproductive toxicity for either Mixed Terphenyls or Quaterphenyls. Thus, we propose to conduct an OECD 421 Reproductive/Developmental Toxicity screen for Mixed Terphenyls and utilize “Read Across” methods for Quaterphenyl evaluation, thus minimizing the number of animals to be tested.

Based on the conclusions as outlined above on HPV Endpoint assessment, following is a tabular depiction of data availability and testing recommendations for Mixed Terphenyls (Table 1) and Quaterphenyls (Table 2).

Table 1. Test Plan Matrix for Mixed Terphenyls

	Info. Avail.	OECD	GLP	Other Study	Estimat. Method	Accept-Able ?	Testing Recomm.
PHYSICAL CHEMICAL							
Melting Point	Y	N	N	Y	N	Y	N
Boiling Point	Y	N	N	Y	N	Y	N
Vapor Pressure	Y	N	N	Y	N	Y	N
Partition Coefficient	Y	N	N	Y	N	Y	N
Water Solubility	Y	N	N	Y	N	Y	N
ENVIRONMENTAL FATE ENDPOINTS							
Photodegradation	Y	N	N	N	Y	Y	N
Stability in Water	N	-	-	-	-	Y	N
Biodegradation	Y	N	N	Y	N	Y	N
Transport between Environmental Compartments (Fugacity)	Y	N	N	N	Y	Y	N
ECOTOXICITY							

Acute Toxicity to Fish	Y	N	Y	Y	N	Y	N
Acute Toxicity to Aquatic Invertebrates	Y	N	Y	Y	N	Y	N
Acute Toxicity to Aquatic Plants	Y	N	Y	Y	N	Y	N
MAMMALIAN TOXICITY							
Acute Toxicity	Y	Y	Y	Y	N	Y	N
Repeated Dose Toxicity	Y	N	N	N	N	Y	N
Genetic Toxicity – Mutation (Ames)	Y	Y	Y	Y	N	Y	N
Genetic Toxicity – Chromosomal Aberrations	Y	Y	Y	Y	N	Y	N
Reproductive Toxicity	N	-	-	-	-	N	Y

Y = Yes; N = No; C = Read-Across from Isomers (o-, m-, and p-); - = Not applicable

Table 2. Test Plan Matrix for Quarterphenyls

	Info. Avail.	OECD	GLP	Other Study	Estimat. Method	Accept-Able ?	Testing Recomm.
PHYSICAL CHEMICAL							
Melting Point	Y	N	N	Y	N	Y	N
Boiling Point	Y	N	N	Y	N	Y	N
Vapor Pressure	Y	N	N	Y	N	Y	N
Partition Coefficient	Y	N	-	-	Y	Y	N
Water Solubility	Y	N	Y	Y	N	Y	N
ENVIRONMENTAL FATE ENDPOINTS							
Photodegradation	Y	-	-	-	Y	Y	N
Stability in Water	N	-	-	-	-	Y	N
Biodegradation	Y	N	N	Y	N	Y	N
Transport between Environmental Compartments (Fugacity)	Y	-	-	N	Y	Y	N
ECOTOXICITY							

Acute Toxicity to Fish	N	-	-	C	Y	Y	N
Acute Toxicity to Aquatic Invertebrates	Y	Y	Y	N	Y	Y	N
Acute Toxicity to Aquatic Plants	N	-	-	C	Y	Y	N
MAMMALIAN TOXICITY							
Acute Toxicity	Y	N	N	N	N	Y	N
Repeated Dose Toxicity	N	-	-	C	-	Y	N
Genetic Toxicity – Mutation (Ames)	N	-	-	C	-	Y	N
Genetic Toxicity – Chromosomal Aberrations	N	-	-	C	-	Y	N
Reproductive Toxicity	N	-	-	-	-	N	C

Y = Yes; N = No; R = Reputable Reference; ; - = Not applicable
C = Read-Across from available data or new testing on Mixed Terphenyls

V. Data Set Summaries and Evaluations

The key studies used in this assessment to fulfill the HPV requirements for Mixed Terphenyls and Quaterphenyls have been placed in an Endpoint-specific matrix, and further discussed below. Additionally, we have provided reference to similar studies conducted with one or more component isomeric forms, which have been included in the discussions below. Robust Summaries for each study referenced, whether it be for the Mixed isomer component or the individual isomers, can be found in Section VII of this dossier.

A. Chemical/Physical Properties

Measured values are available for most of the **Physical-Chemical** properties associated with Solutia's Mixed Terphenyls commercial products and can be found in Table 3. A calculated value, using an EPA recommended methodology, for each Endpoint has been included for comparative purposes and confirms good agreement between calculated and measured values. Thus, these values are considered "2-Reliable with restrictions". In most cases, measured values, obtained from either reputable references or from internal studies, have also been obtained for each of the 3 terphenyl isomers predominant in Mixed Terphenyls. Visual inspection of these values provides corroborating support for values provided for Mixed Terphenyls. A Robust Summary has been prepared for each of the references included in Table 3.

Similar to the Mixed Terphenyls, measured physical-chemical properties have been located for Solutia's Quaterphenyls commercial product. Additionally, we have provided values for each physical-chemical Endpoint using estimation models recommended by EPA and that were used to derive values for Mixed Terphenyls and its isomers. Where measured data are not available, it is reasonable to assume that models providing accurate values for 3-phenyl ring compounds (terphenyls) would also provide similarly useful values for 4-phenyl ring compounds (the quaterphenyls). Hence, these estimations also are considered "2-Reliable with restrictions" and fulfill the data needs for Quaterphenyls.

In summary, Mixed Terphenyls and Quaterphenyls are solid, waxy-like entities at room temperature and possess exceedingly low vapor pressures. Waxiness, and hence Boiling and Melting Point, increase as vapor pressure decreases even further with the addition of another phenyl ring (between terphenyls and quaterphenyls) and as molecular weight increases. Mixed Terphenyls have a relatively high measured partition coefficient which is quite similar to its estimated value; as expected, Quaterphenyls have an even higher calculated value. All water solubility values, for Mixed Terphenyls, its isomeric components and the Quaterphenyls, establish this category of chemicals as possessing very low (< 0.1 ppm) water solubility.

Conclusion: Sufficient data exists to characterize the Physical-Chemical properties of the Mixed Terphenyls and Quaterphenyls. Measured values were corroborated by comparing estimated and measured values and then were compared to similar values obtained for each of the 3 isomeric forms of Terphenyls found in Mixed Terphenyls. Thus, all HPV data requirements for this Endpoint have been met and no further data collection is planned.

Table 3. Selected Physical Properties of Polyphenyls (3- & 4-Phenyl Rings) and Surrogates

Chemical	Boiling Pt. (^oC.)	Melting Pt. (^{o} C.)	Vapor Pressure (hPa @ 25 ^oC)	Water Solubility (mg/L)	Partition Coeffient (Log Kow)
Mixed Terphenyls CAS No. 26140-60-3	**376 deg. C (calculated)**	**210.1 deg. C. (calculated)**	**0.00000412 (calculated)**	**0.215 mg/L (calculated)**	**5.52 (calculated)**
SANTOWAX R ® Mixed Terphenyls (81% Terphenyls; 17% Quaterphenyls)	**364**	**145**		**0.11**	**5.21 (calculated)**
THERMINOL 75 ® Mixed Terphenyls (62% Terphenyls; 34 % Quaterphenyls)	**343**	**76**	**0.0000081**	**0.151**	**6.03** **5.16 (calculated)**
o-Terphenyl (Surrogate) CAS No. 84-15-1	332	56.2	0.0003	1.24	5.28 (measured) ---- 5.52 (calculated)
m-Terphenyl (Surrogate) CAS No. 92-06-8	363	87	0.0000233	1.51	5.52 (calculated)
p-Terphenyl (Surrogate) CAS No. 92-94-4	376	210.1	0.000000456 (calculated)	0.0018	6.03 (measured) ------ 5.52 (calculated)
Quaterphenyls CAS No. 29036-02-0	**481.2 (calculated)**	**184.1 (calculated)**	**0.0000000023 (calculated)**	**0.0068 (calculated)**	**7.28 (calculated)**
SANTOTAR 9 ® Quaterphenyls (90% Quaterphenyls, 10% Terphenyls)	**> 420**	**200**		**0.002**	

Category members emboldened type; Surrogate chemicals in normal type.

C. Environmental Fate and Biodegradation

Shake-flask Ultimate Biodegradability studies have been conducted to assess the biodegradation potential of Mixed Terphenyls and Quaterphenyls; they have been summarized in the Robust Summary section of this Dossier and cited in Table 4 below. While each study was conducted prior to inception of standardized international guidelines for **Biodegradability** testing and GLPs, they followed similar standards for conduct subsequently codified into OECD guideline 302 and GLP documentation. Thus, they are each considered “2-Reliable with restrictions”. A Semi-Continuous Activated Sludge (SCAS) assay with Mixed Terphenyls is also included as it was well documented and thus also considered “2-Reliable with restrictions”. For comparative purposes, similar Shake Flask studies and a River Die Away study with the three terphenyl isomers are provided as supplemental information and summarized in Section VII. Studies confirm that Mixed Terphenyls and Quaterphenyls undergo very slow biodegradation.

A single, comparative study of the photochemical reactions associated with each of the three terphenyl isomers has been summarized in the Robust Summary section of this dossier. This study has been classified as “2-Reliable with restrictions”, as it provides useful Supplemental information, appears well conducted, but did not conform to codified OECD guidelines. Comparative values have been included in Table 4. No photodegradation testing was found for Mixed Terphenyls. However, based on the limited photodegradation exhibited by each of these terphenyl isomers, little appreciable photodegradation of the Mixed Terphenyls is expected to occur. Based on a “Read Across” approach using these results from its predominant isomers, this HPV Endpoint for Mixed Terphenyls is considered adequate. AOPWIN modeling for this **Photodegradation** Endpoint has also been included for comparative purposes and has been coded as “2-Reliable with restrictions”.

Estimation of **photolysis** of Quaterphenyls through use of a model similar to that employed for Mixed Terphenyls also indicates little, if any, likelihood of photolysis. This study is also considered “2-Reliable with restrictions”. Based on model estimation and structural similarity to Mixed Terphenyls, there would appear to be no need to further establish this Endpoint experimentally.

We have incorporated the use of an estimation model (EPIWIN, 2002) for determination of Transport Between Environmental Compartments (**Fugacity),** for Mixed Terphenyls and Quaterphenyls, as well as the terphenyl surrogate isomers**.** A Fugacity Level III model was used in each case, and employed measured values, where possible, as recommended by the US EPA. Thus, the estimations derived from each of these models have been classified as “2-Reliable with restrictions”. These estimates have also been included in Table 4 and are cited in the Robust Summary section of this Dossier; data entries used in the Level III fugacity model have been included in the Robust Summaries for validation of output.

No values have been identified to define the **Stability in Water** (hydrolysis) of any of these Polyphenyls. Further no such values could be calculated using EPIWIN (2002) as each chemical has only aromatic rings and no functional groups, and thus form structures which are listed in Lyman et al. (1990) as “Generally Resistant to Hydrolysis”. Thus, “[t]esting for Stability in Water is not needed for substances generally recognized to have molecular structures or possess only functional groups that are generally known to be resistant to hydrolysis” (OECD, 2002).

Conclusion: Sufficient information exists to characterize the Environmental Fate and Biodegradation of each of these Polyphenyls. Where experimental data do not

exist, employing "Read Across" techniques or using an estimation model (AOPWIN and EPIWIN) recommended by EPA provided necessary information; in one case (hydrolysis) the rational lack of need for testing has already been recognized. Thus, all HPV data requirements for these Endpoints are met and no further data collection is planned.

To summarize, this Category of chemicals would not be expected to normally enter the aquatic environment, as the products which contain these chemicals are not intended to be discharged to the environment. However, their limited entry could be envisioned after incidental spills and equipment leakage. Thus, the Environmental fate of these Polyphenyls, based on Fugacity modeling of the members of this Category, is expected to be focused primarily in the soil and sediment as main environmental target compartments. None of these chemicals is readily hydrolysable, all have exceedingly low water solubility characteristics, and would be expected to undergo limited photolysis in the environment. As part of the soil or sediment, these chemicals are expected to extensively degrade. In soil studies with Mixed Terphenyls, extensive biological degradation occurred in soils studies with T ½ lives ranging betwee n 8-12 weeks. Additionally, rapid primary biodegradation of the two most water-soluble Terphenyl isomers occurred in River Die Away tests, once acclimation ensued.

Table 4. Comparison of Environmental Fate Endpoints for Category Members

Chemical	Biodegradation Rate	Stability in Water	Photodegradation (% Disappeared- 29 days Irradiation)	Fugacity (%)
Mixed Terphenyls CAS No. 26140-60-3		**Not susceptible to hydrolysis**	**Half-life = 27.9 hrs (calculated)**	**Air - 1.05% Water- 12.0% Soil- 43.8% Sediment- 43.1%**
SANTOWAX R ® Mixed Terphenyls (81% Terphenyls; 17% Quaterphenyls)	**11.5% Mean Disappearance in SCAS**	**Not susceptible to hydrolysis**		
THERMINOL 75 ® Mixed Terphenyls (62% Terphenyls; 34 % Quaterphenyls)	**7-10% Theoretical CO_2 formed-Shake Flask Ultimate Biodegradation**	**Not susceptible to hydrolysis**		
o-Terphenyl (Surrogate) CAS No. 84-15-1	20 % Theoretical CO_2 formed- Shake Flask Ultimate Biodegradation	Not susceptible to hydrolysis	< 8 (measured) ------ Half-life = 27.9 hrs (calculated)	Air- 1.29% Water- 14.7 % Soil- 50.9 % Sediment-33 %
m-Terphenyl (Surrogate) CAS No. 92-06-8	38 % Theoretical CO_2 formed- Shake Flask Ultimate Biodegradation	Not susceptible to hydrolysis	14 (measured) ------ Half-life = 20.3 hrs (calculated)	Air- 0.87% Water- 11.8 % Soil- 45 % Sediment- 42.4 %
p-Terphenyl (Surrogate) CAS No. 92-94-4	10 % Theoretical CO_2 formed in Shake Flask Ultimate Biodegradation	Not susceptible to hydrolysis	< 10 (measured) ------ Half-life = 27.9 hrs (calculated)	Air- 1.06% Water- 11.7 % Soil- 45.3 % Sediment-41.9 %
Quaterphenyls CAS No. 29036-02-0		**Not susceptible to hydrolysis**	**Half-life = 13.8 hrs (calculated)**	**Air- 0.22% Water- 3.47 % Soil- 32.3 % Sediment-64 %**
SANTOTAR 9 ® Quaterphenyls (90% Quaterphenyls, 10% Terphenyls)	**7 % Theoretical CO_2 formed in Shake Flask Ultimate Biodegradation**	**Not susceptible to hydrolysis**		

Category members emboldened type; Surrogate chemicals in normal type.

D. Aquatic Toxicity

Experimental data have been found with Mixed Terphenyls for all three aquatic toxicity Endpoints. In each case, a well conducted study, following international testing and GLP guidance has been summarized in Table 5 and further described in the Robust Summary section of this dossier. In each case, these studies are considered “2-Reliable with restrictions”. Also reported in the Robust Summary section of this dossier are the results of an Early Lifestage chronic fish study with Mixed Terphenyls using Fathead Minnows, which has be classified as “1-Reliable without restriction”. The NOEC of 0.037 mg/L reported in that study is also consistent with the degree of toxicity exhibited in acute studies with other aquatic species. Both measured and estimated values for acute aquatic toxicity of each of the three Mixed Terphenyls isomers are also reported in Table 5. These values are consistent with values obtained for the Mixed Terphenyls products. This Supplemental data has been summarized in the respective Robust Summary section of this dossier.
Experimental results for all three species compare favorably with estimated values using the ECOSAR model. In all cases, Mixed Terphenyls exhibit a high degree of aquatic toxicity.

An acute Daphnia study, considered “2-Reliable with restrictions” has been conducted with Quarterphenyls. It too is indicative of a high degree of toxicity, as seen with Mixed Terphenyls. No acute fish or algal studies have been located for Quaterphenyls. However, in as much as the Invertebrate study confirms its high aquatic toxicity potential, as does ECOSAR modeling (which gave good congruence between experimental and modeled estimates for these endpoints with Mixed Terphenyls) for acute fish and algal toxicity, it is concluded that no additional acute aquatic testing is needed to confirm the self evident, that Quaterphenyls possess a degree of aquatic toxicity similar to that observed with Mixed Terphenyls across aquatic species.

Conclusion: Sufficient data exists to characterize the Acute Aquatic Toxicity properties of each of these Polyphenyl Category members. All HPV data requirements for this Endpoint have been met with acceptable empirical data for Mixed Terphenyls. We have used accepted, validated estimation models coupled with experimental data for Quaterphenyl to provide information needed such that no further data collection is required for either of these materials.

Table 5. Comparison of Aquatic toxicity parameters for Category members and Surrogates

Chemical	Fish LC 50 (mg/L) (96-hr)	Chronic Fish NOEC (mg/L)	Invertebrate (Daphnia) EC50 (mg/L) (48-hr)	Algae EC50 (mg/L) (96-hr)
Mixed Terphenyls CAS No. 26140-60-3	**0.028 (calculated)**		**0.039 (calculated)**	**0.031 (calculated)**
SANTOWAX R ® Mixed Terphenyls (81% Terphenyls; 17% Quaterphenyls)	**27 (R. trout)**		**0.27**	**0.015 (chlorophyl a)** **0.020 (cell number)**
THERMINOL 75 ® Mixed Terphenyls (61% Terphenyls; 34% Quaterphenyls)	**> 0.75 (P. promelus)**	**0.037**	**0.043**	**0.103 (cell number)**
o-Terphenyl (Surrogate) CAS No. 84-15-1	0.084 (calculated)		0.045 (measured) 0.115 mg/L (calculated)	0.088 (calculated)
m-Terphenyl (Surrogate) CAS No. 92-06-8	0.084 (calculated)		0.022 (measured) 0.115 mg/L (calculated)	0.088 (calculated)
p-Terphenyl (Surrogate) CAS No. 92-94-4	0.028 (calculated)		> 5.5 (measured - exceeded water solubility) 0.039 mg/L (calculated)	0.031 (calculated)
Quaterphenyls CAS No. 29036-02-0	**0.002 (calculated)**		**>0.069 (measured)** **- - -** **0.004 (calculated)**	**0.003 (calculated)**

Category members emboldened type; Surrogate chemicals in normal type.

D. Mammalian Toxicity

1.0 Acute Toxicity

Key acute toxicity studies by the oral exposure route for Mixed Terphenyls and Quaterphenyls are included in Table 6. Each study was conducted specifically or in general agreement with OECD acute toxicity testing guidance and are considered "1-Reliable without restriction" and "2-Reliable with restrictions", respectively. The Mixed Terphenyl study cited was conducted with a 99%:1% Terphenyl-to-Quaterphenyl mixture which was high in meta- and para- isomers, and low (<1%) in ortho-terphenyl. Additional acute rat oral toxicity studies, conducted with a lower ratio of terphenyls-to-quaterphenyls (61% terphenyls:34% quaterphenyls) have been included in Table 6 and cited in the Robust Summary section of this dossier.

Acute rat oral LD50 values for each of the three terphenyl isomers found in Mixed Terphenyls were found in the literature (Cornish, Bahor and Ryan, 1962), are reported in Table 6, and are summarized as Supplemental information in the Robust Summary section of this dossier.

Conclusion: Sufficient data from well-documented studies (Acute Oral Toxicity) exist to meet the Acute Toxicity data set requirements for Mixed Terphenyls and Quaterphenyls. Hence, no further acute toxicity testing is planned.

Table 6. Acute Mammalian Toxicity for Category members

Chemical	Rat Oral LD50 (mg/kg)	Repeated Dose (Oral studies)	Mutagenicity Salmonella Test	Cytogenetics
SANTOWAX MP ® Mixed Terphenyls CAS No. 26140-60-3 (>99 % Terphenyls)	**> 5,000**			
SANTOWAX OM ® Mixed Terphenyls CAS No. 26140-60-3 (96 % Terphenyls; 4 % Quaterphenyls)	**1400**	**235-d rat chronic: NOEL= 3 mg/kg/d**		
SANTOWAX R ® Mixed Terphenyls (81% Terphenyls; 17% Quaterphenyls)			**Negative without S-9 TA 1535, 1537, 1538, 98, 100 and D4 yeast; neg. with S9 in TA 1535, 1537, 1538, 98; pos. TA 100** **Negative: +/- S-9 CHO/HGPRT Assay**	**Negative -CHO cell cytogenicity assay +/- S-9**
THERMINOL 75 ® Mixed Terphenyls (61% Terphenyls; 34 % Quaterphenyls)	**2604**		**Negative +/- S-9 TA 1535, 1537, 1538, 98, 100 and D4 yeast** **Negative: +/- S-9 CHO/HGPRT Assay**	**Negative: rat bone marrow *in vivo* assay**
o-Terphenyl (Surrogate) CAS No. 84-15-1	1,900	30-d rat: NOEL=100 mg/kg	Neg-strain TM667 +/- S-9	
m-Terphenyl (Surrogate) CAS No. 92-06-8	2,400	30-d rat: NOEL=100 mg/kg	Neg-strain TM667 +/- S-9	
p-Terphenyl (Surrogate) CAS No. 92-94-4	> 10,000	30-d rat: NOEL=250 mg/kg		
SANTOWAX Q ® Quaterphenyls CAS No. 29036-02-0 (95 % Quaterphenyls; 5 % Terphenyls	**5,650**			

Category members emboldened type; Surrogate chemicals in normal type.

2.0 Repeated Dose Toxicity

A chronic rat study with Mixed Terphenyls has been published in the scientific literature and is cited in Table 6. While conducted well before development of OECD test guidelines or GLPs, this study is considered sufficient to meet this HPV Endpoint, for it greatly exceeds the minimum duration necessary for consideration and has included most of the testing endpoints included in those guidelines. Based on the thoroughness of its design and duration, this study is considered sufficient to evaluate the repeated dose toxicity of Mixed Terphenyls and thus has been judged as “2-Reliable with restrictions”.

This study used a test material consisting of 95% Terphenyls and 5% Quaterphenyls. By comparison, this material was higher in the ortho-terphenyl isomer content (64% ortho-) than found in commercial Mixed Terphenyls, which contain <2% ortho-isomer. Based on 30-day oral rat studies conducted with each of the Terphenyl isomers (Table 6), the ortho-isomer is considered quantitatively similar in toxicity to the meta- terphenyl isomer; comparatively, the para-isomer appears relatively of lesser toxicity. Effects on body weight and organ weights were observed after 30-days of treatment with either the o- or m- isomer and each produced a NOEL of 100 mg/kg day (Table 6). As each of the commercial Mixed Terphenyls contains significant amounts of meta-isomer (> 55%), their repeated dose toxicity can be expected to be similar to that of the material used in this chronic study.

No repeated dose toxicity studies have been found for Quaterphenyls. However, based on the similarity of structure and physical properties between the Mixed Terphenyls and Quaterphenyls, a similarity of biological response would be anticipated. Thus, rather than conduct of unnecessary additional repeated dose toxicity testing, use of the “Read across” technique has been employed to render the need for similar testing with Quaterphenyls unnecessary.

Conclusion:
Based on conduct of an acceptable chronic oral rat study with Mixed Terphenyls and assessment of 30-day oral rat studies with each of the three Terphenyl isomers, the Repeated Dose Toxicity HPV Endpoint for Mixed Terphenyls is complete. While no studies were found for Quaterphenyls, use of “Read across” for Quaterphenyls negates the need for additional testing for this Endpoint.

3.0 Mutagenicity and Chromosomal Aberrations

<u>Ames Test</u>

Three Ames point mutation studies have been conducted with Mixed Terphenyls. Two studies were conducted with THERMINOL 75 (61% Terphenyl:36% Quaterphenyl) and one with SANTOWAX R (81% Terphenyl:17% Quaterphenyl). All studies conformed to

OECD Test Guideline 471, athough only one (with THERMINOL 75) was conducted in accord with GLPs. Thus, the two studies conducted prior to inception of GLPS are considered "2-Reliable with restrictions" while the other is considered "1-Reliable without restriction". All three studies have been summarized in the Robust Summary of this dossier. Two studies reported no mutagenic response in any of the 5 Salmonella tester strains used, with or without metabolic activation. The third study reported a positive response only in TA100 with, but not without, metabolic activation. No mutagenic responses were observed in other Salmonella strains used. Weight-of-evidence among these three studies would indicate that Mixed Terphenyls do not elicit a genotoxic response in this assay. Further confirmation of a lack of Genotoxicity via point mutations can be found in the results of two mammalian cell point mutation studies with THERMINOL 75 and SANTOWAX R. No mutagenic activity was observed in either of two independently conducted CHO/HGPRT mammalian forward mutation assays (Solutia, 1984a, Solutia, 1986a). Robust Summaries of each of these studies has been included in this dossier.

No point mutation assays have been found evaluating Quaterphenyls. Using the "Read Across" methodology, we believe it appropriate to apply results reported above which was obtained from testing Mixed Terphenyl fractions containing substantive amounts of Quaterphenyls.

Conclusion: The Ames Test Category Endpoint for each of the Category members has been met and no further testing should be considered for the gene point mutation Endpoint.

Chromosomal Aberrations -

An *in vitro* CHO cell chromosomal aberration study has been conducted with an 81:17 ratio of Terphenyls:Quaterphenyls (SANTOWAX R) following a study design similar to OECD Test guideline 473. The study was well documented and followed GLPs and thus is considered to be "1-Reliable without restriction". Additionally, an *in vivo* mouse bone marrow cytogenetics assay has been conducted with a 62:34 ratio of Terphenyls:Quaterphenyls (THERMINOL 75). It, too, conforms to OECD testing guidance (guideline no. 475) and is considered "1-Reliable without restriction". These studies have been used to fulfill this HPV Endpoint for Mixed Terphenyl. Each study has been referenced in Table 6 and summarized in the Robust Summary section of this dossier. No evidence of chromosomal aberrations were observed in either study.

No chromosomal aberration studies have been located with Quaterphenyl. Using the "Read Across" methodology, we believe it appropriate to apply results reported above obtained for Quaterphenyls.

Conclusion: On the basis of reliable *in vitro* and *in vivo* Chromosomal Aberration Assays available for Mixed Terphenyls and use of "Read Across" for Quaterphenyls in lieu of unnecessary testing, this HPV Endpoint has been fulfilled.

5. Reproductive and Developmental Toxicity

No reliable evaluation of reproductive parameters has been found either in the open literature or in search of in-house files for either Mixed Terphenyls or Quaterphenyls.

Reproductive organs were evaluated in a chronic rat study reported for Mixed Terphenyls in the Repeated Dose section of this dossier. No effects were noted either in organ weights or weight ratios or following histopathological evaluation of testes or ovaries following 235 days of oral exposure up to 350 (male)/409 (female) mg/kg/day Mixed Terphenyls. Similarly, no effects on rat gonads were reported following 30 days of oral exposure to m-, p-, or o-terphenyl. Thus, there is no evidence that Mixed Terphenyls or Quaterphenyls would be expected to affect reproductive performance.

A single mouse *in vitro* fertilization study with each of the 3 Terphenyl isomers was found in the literature. Due to deficiencies in design this study has been classified for reliability as “3- Not reliable”. However, it has been included in the Robust Summary section of each Terphenyl isomer as Supplemental information.

Conclusion: In light of the ambiguity of the *in vitro* experimental data addressing the potential of individual Terphenyl isomers to affect reproductive outcome, we are prepared to conduct a Reproductive/developmental toxicity screen test (OECD 421) with Mixed Terphenyls. With results obtained from this study, the “Read Across” technique will be applied to Quaterphenyls, in order to minimize the unnecessary use of additional animals.

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VII. ROBUST STUDY SUMMARIES

Study Summaries Appended for Mixed Terphenyls and Quaterphenyls, and also o-, m-, and p-Terphenyl.