TC NES SUBGROUP ON IDENTIFICATION OF PBT AND VPVB SUBSTANCES

RESULTS OF THE EVALUATION OF THE PBT/VPVB PROPERTIES OF:

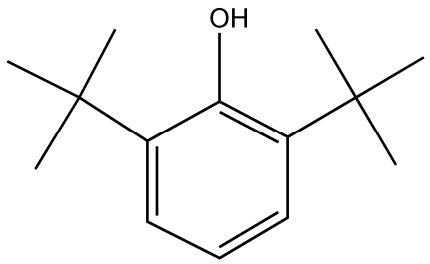
Substance name: 2,6-di-tert-butylphenol

EC number: 204-884-0

CAS number: 128-39-2

Molecular formula: C14H22O

Structural formula:



Summary of the evaluation:

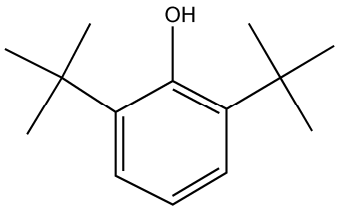
The substance is not considered to be a PBT substance. This conclusion applies for the parent compound only.

The substance does not meet the B criterion. It may meet the P/vP criteria based on screening data. Although the substance and a structurally similar compound 2,6-di-tert-butyl-m-cresol (BHT; CAS 128-37-0) have been observed to degrade, no estimate of the rate of degradation is available. The assessment of ecotoxicity was not completed.

JUSTIFICATION

1 IDENTIFICATION OF THE SUBSTANCE AND PHYSICAL AND CHEMICAL PROPERTIES

Name: 2,6-di-tert-butyl-phenol
EC Number: 204-884-0
CAS Number: 128-39-2
IUPAC Name:
Molecular Formula: C14H22O
Structural Formula:



Molecular Weight: 206
Synonyms: 2,6-bis(1,1-dimethylethyl)-phenol; phenol, 2,6-bis(1,1dimethylethyl)-; phenol, 2,6-di-tert-butyl; DTBP

1.1 PURITY/IMPURITIES/ADDITIVES

No data available.

1.2 PHYSICO-CHEMICAL PROPERTIES

Table 1 Summary of physico-chemical properties

REACH ref Annex, §	Property	Value	Comments
VII, 7.1	Physical state at 20 C and 101.3 Kpa	solid liquid	Both forms are provided in European Commission (2000)
VII, 7.2	Melting / freezing point	34-39ºC 36-37ºC	MDL Information Systems (date not evaluated) MSDS of Ethyl, Rhone-Poulenc, Shell (data not evaluated)
VII, 7.3	Boiling point	253ºC (at 1013 hPa)	MSDS of Ethyl, Rhone-Poulenc, Shell (data not evaluated)
VII, 7.5	Vapour pressure	0.013 hPa (at 20ºC)	MSDS of Ethyl, Rhone-Poulenc, Shell (data not evaluated)
VII, 7.7	Water solubility	30.7 mg l^{-1} (at 25ºC) 2.5 mg l^{-1} (at 25ºC) 4.11 mg l^{-1} (at 25ºC)	WSKOW v1.41 WSKOW v1.41 exper. database (data not evaluated) OECD (1995)
VII, 7.8	Partition coefficient n-octanol/water (log value)	4.48 4.92	KOWWIN v1.67 KOWWIN v1.67 exper. database (data not evaluated)
	Dissociation constant	8-11	For hydroxylated aryl compounds (Rochester, 1971) (data not evaluated)

2 MANUFACTURE AND USES

Ten sites have notified the substance. According to European Commission (2000), a quantity of 10,000-50,000 tpa is produced and/or imported in Europe. According to industry, the substance has two fields of application. A minor part is used as a stabilizer in jet fuel and the main volume is used for the production of phenolic antioxidants and UV-stabilizers.

3 CLASSIFICATION AND LABELLING

The substance is not classified in the Annex I of Directive 67/548/EEC.

4 ENVIRONMENTAL FATE PROPERTIES

4.1 DEGRADATION (P)

4.1.1 Abiotic degradation

No standard experimental data are available on 2,6-di-tert-butylphenol. A structurally similar compound 2,6-di-tert-butyl-m-cresol (BHT; CAS 128-37-0) has been observed to oxidise in water to several transformation products with a moderate to rapid rate in the dark and under sunlight (faster degradation in sunlight) (see PBT summary fact sheet No. 121). In addition, one source (Freitag et al., 1982) indicate that that 2,6-di-tert-butylphenol might be not completely stable in some test conditions.

Freitag et al. (1982) tested photodegradation of the substance with a microphotoreactor. The test substance was dispersed on silica gel at a concentration of approximately 30 ng/g silica gel. The test substance was irradiated with a UV lamp of 290 nm for 17 hours. Volatile organic compounds and CO_2 were collected. As a result, photomineralisation at 29.5% of theoretically possible CO_2 amount was measured. The share of "organic fragments" was < 0.1%. No replicate tests were carried out and the test procedure is only briefly documented. On the basis of the test, it is only possible to state that the possibility of photodegradation in, e.g. in long-term ecotoxicity tests should be excluded by analytical monitoring. The relevance of photodegradation as a major degradation path of 2,6-di-tert-butylphenol in the environment is generally excluded. Photodegradation of 2,6-di-tert-butylphenol could be in the "best case" expected to be a relevant removal pathway in the environment only in very shallow clear waters and in the first few centimeters layer of the water column with some exceptions. Possible aquatic photodegradation is not considered to have relevant impact on the overall persistency of 2,6-di-tert-butylphenol in the environment.

Springborn Laboratories Inc. (1992a) measured indirect photolysis in water according to TSCA Guideline 40 CFR 795-70. The test concentration was 1.25 mg l^{-1}, the test medium contained humic acid as sensitizer (references were run with pure water) and the substance was exposed to natural sunlight (outdoors). The study determined photolysis rates, but the disappearance of the substance in dark controls was very high and the reliability of the results is therefore low. It is noted, that the study report was not available to the Rapporteur for evaluation.

Indirect photochemical degradation in the atmosphere is considered to be fast based on the estimated half-life of 7.8 hours for the reaction with OH-radicals using AOP v1.91 (24-hour day^{-1}; $5*10^5$ OH^- cm^{-3}).

4.1.2 Biotic degradation

A test on ready biodegradability according to OECD 301B (modified Sturm test) resulted with test concentrations of 10 mg l^{-1} and 20 mg l^{-1} in 28 days a mineralization of 5% and 1% (measured as CO_2 –evolution), respectively (Ciba-Geigy, 1987). The study report was not available to the Rapporteur for evaluation. BIOWIN v4.02 predictions support the result.

Freitag et al. (1982) measured degradation of ^{14}C-labelled 2,6-di-tert-butylphenol in domestic activated sludge (1 g dw l^{-1}). Test concentration was 50 µg l^{-1}, incubation lasted 5 days at 25 ± 1°C and volatiles and CO_2 were trapped in soda lime for analysis. According to results, 7.7% of the substance was volatilised, 1.1% mineralised, 29.8% measured as metabolites in water phase, 15.1% measured as metabolites in sludge and 31.9% measured as non extractable residues. Presumably,

14% of parent compound remained in the test solution. The study is not a standard test. The test concentration is very low and the concentration of sludge inoculum is high compared to a biodegradation screening test and the procedure is not well documented. In addition, no replicates were carried out. Based on these considerations it is not possible to compare these results with the standard biodegradation screening results. This study, however, provides an indication on that 2,6-di-tert-butylphenol might be biodegradable although no estimate of degradation rate can be reduced from the result. Korte and Klein (1982) and Freitag et al. (1985) report results of a similar test as Freitag et al. (1982) with activated sludge. Springborn laboratories Inc. (1992b) observed no degradation during 56 days in an anaerobic sludge biodegradation test according to TSCA test guideline 796.3140 (comparable with OECD 311).

The structurally similar substance BHT has been observed to be degraded in soil via biological and abiotic processes (see PBT summary fact sheet No. 121).

4.1.3 Other information [1]

Jungclaus et al. (1978) analysed waste water, the receiving river water and sediment at a chemical manufacturing site in the United States for a number of phenolic compounds including 2,6-di-tert-butylphenol. In addition, Lopez-Avila and Hites (1981) analysed 2,6-di-tert-butylphenol in sediment samples from the same river. The authors observed a connection between a decrease of 2,6-di-tert-butylphenol concentration and an increase of 2,6-di-tertbutylbenzoquinone concentration (aerobic conditions) suggesting this to be the main degradation product. A reverse relationship was observed in anaerobic sediment layers indicating that the degradation product was partly reduced back to 2,6-di-tert-butylphenol. It is not possible to derive biodegradation rates from these studies.

4.1.4 Summary and discussion of persistence

2,6-di-tert-butylphenol is not readily biodegradable but it can be expected to be oxidised in aquatic solution and possibly be subject to biodegradation based on the data on the structurally similar substance BHT. In addition, one (aerobic) biodegradation test with sludge and two monitoring studies provide an indication that 2,6-di-tert-butylphenol might be biodegradable. In the lack of information on the rate of primary degradation, identity of degradation products and mineralisation, no conclusion can be made on the persistence of the substance, but further testing would be necessary on abiotic and biological degradation.

4.2 ENVIRONMENTAL DISTRIBUTION

Data not reviewed for this report.

4.2.1 Adsorption

4.2.2 Volatilisation

4.2.3 Long-range environmental transport

[1] For example, half life from field studies or monitoring data

4.3 BIOACCUMULATION (B)

4.3.1 Screening data[2]

Using the logKow of 4.92, a BCF of 435 was derived by BCFWIN v2.15.

4.3.2 Measured bioaccumulation data[3]

A BCF of 128-436 has been derived by MITI (1992) for the isomer 2,4-di-tert-butylphenol (CAS 96-76-4). For study details, see PBT summary fact sheet No. 12.

Freitag et al. (1982) measured bioaccumulation of 2,6-di-tert-butylphenol (^{14}C at U-ring) in five specimen of *Leuciscus idus* melanotus. The fish were exposed in a static system five days at a nominal test concentration of 50 µg l^{-1}, whereas the measured exposure concentration was 37 µg l^{-1}. A BCF of 660 was reported as the ratio of ^{14}C between fish and water at day 3. The BCF obtained cannot be considered reliable while it can be assumed that steady state had not been reached in three days. In addition, the difference between measured concentration at day 3 and nominal test concentration indicates that part of the test substance had been degraded and exposure to degradation products was occurring simultaneously. In addition, analysis of ^{14}C-labelled test substance would include also the accumulation of transformation products in the result. Hence, the results of the study may as well underestimate as overestimate the actual BCF.

4.3.3 Other supporting information[4]

No data available.

4.3.4 Summary and discussion of bioaccumulation

Based on the predicted BCF and reading across from the experimental BCF on the isomer 2,4-di-tert-butylphenol, it is concluded that 2,6-di-tert-butylphenol has a moderate bioaccumulation potential.

5 HUMAN HEALTH HAZARD ASSESSMENT

Data not reviewed for this report.

2 For example, log K_{ow} values, predicted BCFs

3 For example, fish bioconcentration factor

4 For example, measured concentrations in biota

6 ENVIRONMENTAL HAZARD ASSESSMENT

6.1 AQUATIC COMPARTMENT (INCLUDING SEDIMENT)

The substance may volatilise, degrade or adsorb to the test system surfaces in test conditions typical for testing effects. Therefore only flow through tests and semi-static tests with test concentration monitoring are capable to produce reliable information on the effects of the test substance whereas results of static tests must be considered as less reliable.

6.1.1 Toxicity test results

6.1.1.1 Fish

Acute toxicity

A flow-through test with *Oncorhynchus mykiss* and test concentrations of 0.74-1.4 mg l^{-1} resulted a LC_{50} (96-hour) > 1.0 mg l^{-1} (Ethyl Corp., 1989). Acetone was used as solvent. No information on monitoring of test concentration is available and the result may therefore be biased. A LC_{50} (7-day) of 0.89 mg l^{-1} and a LC_{50} (14-day) of 0.74 mg l^{-1} were also observed. The study report was not available to the Rapporteur for evaluation.

According to Ethyl Corp. (1989), 2,6-di-tert-butylphenol was tested on *Pimephales promelas* in a flow through system. A LC_{50} (96-hour) at 1.4 mg l^{-1}, a LC_{50} (7-day) at 1.1 mg l^{-1} and a LC_{50} (14-day) at 1.0 mg l^{-1} were found. No information is available whether monitoring of the test concentrations occurred and the result may therefore be underestimating the actual toxicity. Acetone was used as solvent. The study report was not available to the Rapporteur for evaluation.

In a static test according to OECD 203 using *Brachydanio rerio* LC_{50} (96-hour) of 10 mg l^{-1} (nominal) was observed. Acetone was used as solvent (Ciba-Geigy, 1987). This study is not reliable as the concentration of 2,6-di-tert-butylphenol can be expected to decrease in a static test. The study report was not available to the Rapporteur for evaluation.

ECOSAR v0.99h predicts a LC_{50} (96-hour) of 0.5 mg l^{-1} for fish (logKow 4.92 used), which is below the result of Ethyl Corp. (1989).

Long-term toxicity

No experimental data are available. Long-chain alkyl phenols like nonyl phenol and p-tert octyl phenol are known to have endocrine disrupting properties. Also alkyl phenols with shorter alkyl chains have shown endocrine disrupting properties. For p-tert pentyl phenol there are evidence from both *in vitro* and *in vivo* studies and p-tert butyl phenol has shown affinity to the ER-receptor in vitro. The estrogenic activity of 73 phenolic substances including 2,6-di-tert-butylphenol was investigated by Miller et al. (2001) in an *in vitro* recombinant yeast assay where the binding of the test substance to the human estrogen receptor was measured. The estrogenic potency of 2,6-di-tert-butylphenol relative to 17β-estradiol was estimated to 1/20,000,000.

6.1.1.2 Aquatic invertebrates

Acute toxicity

Daphnia magna was exposed in a flow through system for 48 hours to five test concentrations (0.076 to 0.59 mg l^{-1}; measured) of 2,6-di-tert-butylphenol. An EC_{50} (48-hour) of 0.45 mg l^{-1} was obtained (Ethyl Corporation to EPA/OTS, 1989). The study report was not available to the Rapporteur for evaluation.

Gammarus fasciatus was exposed in a flow through system for 48 hours to five test concentrations (0.023 to 1.1 mg l^{-1}; measured) of 2,6-di-tert-butylphenol. LC_{50} (96-hour) of 0.6 mg l^{-1} was obtained (Ethyl Corporation to EPA/OTS, 1989). The study report was not available to the Rapporteur for evaluation.

ECOSAR v0.99h predicts an EC_{50} (48-hour) of 0.7 mg l^{-1} for Daphnia (logKow 4.92 used).

Long-term toxicity

No data available.

6.1.1.3 Algae and aquatic plants

Springborn Laboratories Inc. (1992) reported on a static 96-hour growth inhibition test with *Selenastrum capricornutum* according to the test guideline TSCA 797.1050. Three replicates at six test concentrations (part of the test substance was ^{14}C-labelled) were run in addition to appropriate controls. The test vials were capped to prevent the loss of the test substance. The main deficiencies of the test are described in the following.

The test concentrations were monitored at the 24-hour intervals using mainly HPLC-UV (direct injection of the samples to the eluate). The test concentrations decreased during the course of the test so that at test termination only the two highest test concentrations contained measurable amounts of test material (detection limit = 0.025 mg l^{-1}). The decrease of concentrations was according to a monitoring of the concentration in controls not caused by algae but occurred also in the vials without algae (even slightly faster). Based on the monitoring of the radiolabelled fraction by means of HPLC-RAM and LSC, no degradation products were detected in the test solution but the reason for the disappearance of the test substance remained unclear. In addition, in this test the pH varied from 7.5 at the start to 7.9-9.7 at the end of the test (pH-values not further specified). The variation of the pH is too high according to the present validity requirements. Especially in case of hydroxylated aryl compounds the variation of pH is not acceptable since a significant part of the substance can be expected to be at pH > 8 in dissociated form, which is generally anticipated to exhibit lower toxicity than the undissociated form. It is also not clear from the method description, whether the HPLC elution method has covered the concentration of both species or of only one of the species. The cell growth remained below the presently required 16-fold increase in the controls probably due to the lack of adequate gas exchange. Reference controls without sealing exhibited appropriate growth during the test.

The author reports on an EC_{50} (72-hour) of 1.4 mg l^{-1} (0.58-3.6 mg l^{-1} for 95% c.l.) and on a NOEC (96-hour) of 0.64 mg l^{-1} based on time weighted means of measured concentrations. Due to the several deficiencies these results must be considered as overestimates of the actual values. In addition, the detection limit, which was reached in most of the test flasks, is too high for the derivation of reliable time weighted means of measured concentrations in order to be relevant for a

PBT –assessment, where a NOEC of < 0.01 mg l^{-1} should be measurable. It is noted, that only a robust study summary was available for the Rapporteur for evaluation.

OECD (1995) reports that two attempts to test *Selenastrum capricornutum* according to OPPT test guidelines failed due to the instability of the substance. ECOSAR v0.99h predicts an EC_{50} (96-hour) of 0.27 mg l^{-1} for green algae (logKow 4.92 used).

6.1.2 Sediment organisms

No data available.

6.1.3 Other aquatic organisms

No data available.

6.2 TERRESTRIAL COMPARTMENT

No data available.

6.3 ATMOSPHERIC COMPARTMENT

No data available.

7 PBT AND VPVB

7.1 PBT, VPVB ASSESSMENT

Persistence: 2,6-di-tert-butylphenol may meet the P/vP criteria. The substance is not readily biodegradable but it can be expected to be oxidised in aquatic solution and to be possibly subject to biodegradation based on the data on the structurally similar substance BHT and based on indications from tests with 2,6-di-tert-butylphenol and measured data from the environment. Further testing would be needed to examine the rate of abiotic and biological degradation and the identity of expected transformation products. However, further testing is not required due to the overall conclusion (see below).

Bioaccumulation: 2,6-di-tert-butylphenol does not meet the B criterion. The predicted bioconcentration factor is 538 and the experimental BCF is 128-436 for the isomer 2,4-di-tert-butylphenol. This conclusion applies for the parent compound only.

Toxicity: No experimental long-term ecotoxicity data are available for the substance. Short-term flow-through tests with fish and invertebrates are available but the reliability could not be evaluated as the study reports were not available to the Rapporteur. Two tests with invertebrates resulted EC_{50}–values close to the trigger of 0.1 mg l^{-1}. QSAR-predictions are also close to this value. 2,6-di-tert-butylphenol was found to be a very weak binder to the human estrogen receptor in an in vitro assay and thus is not considered to fulfil the t-criterion with regards to endocrine disrupting effects. For a complete assessment, chronic experimental data would be needed, but such data are not required due to the overall conclusion (see below).

Summary: the substance does not meet the B criterion. It may meet the P/vP criteria. Although the substance and a structurally similar compound 2,6-di-tert-butyl-m-cresol (BHT; CAS 128-37-0) have been observed to degrade, no estimate of the rate of degradation is available. The assessment of ecotoxicity was not completed.

It is concluded that 2,6-di-tert-butylphenol is not considered as a PBT substance. This conclusion applies for the parent compound only.

INFORMATION ON USE AND EXPOSURE

Not relevant as the substance is not identified as a PBT.

OTHER INFORMATION

The information and references used in this report were taken from the following sources:

European Commission (2000) IUCLID Dataset, 2,6-di-tert-butylphenol, CAS 128-39-2, 18.2.2000.

OECD (1995) Screening Information Dataset, 2,6-di-tert-butylphenol, CAS 128-39-2. UNEP Publications.

Other sources:

Freitag D, Geyer H, Kraus A, Viswanathan R, Kotzias D, Attar A, Klein W and Korte F (1982) Ecotoxicological Profile Aanalysis VII. Screening chemicals for their environmental behavior by comparative evaluation. Ecotox. and Env. Safety 6, 60-81.

Jungclaus GA, Lopez-Avila V and Hites RA (1978) Organic compounds in an industrial wastewater: a case study of their environmental impact. Environ. Sci. Technol., No. 12, 88-96.

Lopez-Avila V and Hites R (1981) Oxidation of phenolic antioxidants in a river system. Environ. Sci. Technol., No. 5, 1386-1388.

Miller D, Wheals B, Beresdorf N and Sumpter J (2001) Estrogenic activity of phenolic additives determined by an in vitro yeast bioassay. Environmental Health Perspectives vol.109, No. 2, 133-138.

Rochester CH (1971) In: The Chemistry of the Hydroxyl Group, part 1. Wiley, NY, p. 374 (as cited in Smith MB and March J (2001) March's Advanced Organic Chemistry, 5th edition. John Wiley & Sons, Inc., p. 330).

Springborn Laboratories Inc. (1991) Study Ref.: 91-7-3822 (as cited in Schenectady International, HPV Challenge Program, Study Summaries, Alkylphenols Category. Received by U.S.EPA 19, April, 2006).

Springborn Laboratories (1992a) Test report No. 92-1-4065 (as cited in Schenectady International, HPV Challenge Program, Study Summaries, Alkylphenols Category. Received by U.S.EPA 19, April, 2006).

Springborn Laboratories (1992b) Test report No. 92-2-4 (as cited in Schenectady International, HPV Challenge Program, Study Summaries, Alkylphenols Category. Received by U.S.EPA 19, April, 2006).