

CHEMICAL HAZARD INFORMATION PROFILE*

DRAFT REPORT

Nonylphenol

25154-52-3

September 17, 1985

DISCLAIMER

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*A Chemical Hazard Information Profile (CHIP) is part of the first stage in the assessment of risk by the Office of Toxic Substances (OTS) of chemicals in the 1977 TSCA Chemical Substance Inventory, and enables OTS to decide on a disposition for the subject chemical regarding level of concern and the need for further assessment. The CHIP contains a summary of readily available health, environmental effects, and exposure data. In general, little or no in depth critical evaluation or validation of the data is performed. Several levels of management and technical review have been performed on this CHIP within the Existing Chemical Assessment Division of OTS.

DRAFT REPORT

CHEMICAL HAZARD INFORMATION PROFILE

Subject: Nonylphenol; 4-Nonylphenol; 2-Nonylphenol

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Chemical Name: Nonylphenol (mixed isomers) (9CI)
(CAS No. 25154-52-3)

4-Nonylphenol
(CAS No. 104-40-5)

2-Nonylphenol
(CAS No. 136-83-4)

September 17, 1985

Rationale for Selection: Low LC50 values reported for aquatic invertebrates and fish (Table 9); very high concentrations of nonylphenol found in sewage sludge (Giger et al. 1984); high production volume.

EXECUTIVE SUMMARY

A. Exposure

Technical grade nonylphenol is a mixture of monoalkyl phenols, predominantly para-substituted. The side chains are isomeric branched nonyl groups. The isomer or mixtures cited in the literature are not always specified.

Recent production figures for nonylphenol indicate that 140 million pounds were produced in the United States in 1982, and consumption will increase to 165 million pounds by 1987. Nonylphenol is currently produced by 10 companies, at 13 sites, with no importation occurring.

Industrial manufacture of nonylphenol is by liquid-phase alkylation of phenol with mixed isomeric nonenes in the presence of an acid catalyst. Following production, nonylphenol is stored in drums for later shipment in 55 gallon drums or tank cars. Nonylphenol is rarely used alone as an end product. However, it is used extensively in the production of nonionic ethoxylated surfactants, and to a lesser extent in the manufacture of phosphate antioxidants, oil additives, synthetic lubricants, and corrosion inhibitors.

One of the 13 production sites reports no worker exposures to nonylphenol during 10 years of production and use. No data are available regarding worker exposure to nonylphenol or its isomers at the other 12 production sites, although it is estimated that up to 4 workers/site are dermally exposed during sampling and drumming. Inhalation exposures are expected to be low.

Occupational exposure to nonylphenol during the production of nonylphenol ethoxylates and phosphite antioxidants will be similar, although the latter will be produced at only three sites. Potential exposure may occur while undrumming and charging the nonylphenol to a reactor, and during sampling activities. It is estimated that up to 4 workers/site would be exposed for less than 1 hr/day during these activities, for about 330 days/year. Dermal exposure to nonylphenol would remain low if protective gloves are worn. Inhalation exposure would again be negligible.

There is no information available on consumer exposure to nonylphenol. Consumer exposure to products that may contain nonylphenol can occur during the use of cosmetics, detergents, pesticides, etc. One study detected low levels of nonylphenol in two office buildings, but the source(s) of the nonylphenol was not identified.

A few measurements of nonylphenol in wastewaters have been reported in the literature, and range from 0.002 to 4 mg/L (4-nonylphenol). It has been estimated that only 30 kg/yr will be released during the manufacture of nonylphenol. High levels of 4-nonylphenol were found in stabilized sewage sludge containing surfactants, suggesting origination from anaerobic degradation of alkylphenol ethoxylates. Limited studies indicate that nonylphenol itself is slowly biodegradable.

Although the log P (octanol-water) for nonylphenol is relatively high (4.10), bioconcentration factors in the saltwater mussel, Mytilus edulis were low, ranging from 1.4-13. Studies measuring downstream effluent wastes indicate that nonylphenol is dispersed by the water body and does not accumulate in sediments.

B. Health Effects

A pharmacokinetics study in rats following oral and intraperitoneal administration of ¹⁴C-nonylphenol showed the animals excreted the label in urine (19%) and feces (70%), but not as exhaled CO₂. Ion exchange chromatography indicated that 22% of the urinary metabolites were neutrals, and that the remainder were mainly glucuronic acid conjugates of nonylphenol.

The reported oral ID₅₀ for rats ranges from 580 to 1537 mg/kg and the dermal ID₅₀ for rabbits ranges from 2031 to 3160 mg/day. Mixed nonylphenol

caused moderate necrosis (graded 6 on a scale of 1-10) when applied at a strength of 10 mg/24 hr to rabbit skin. It caused severe corneal damage (graded 10 on a scale of 1-10) as a 1% solution applied to rabbit eyes.

No information was found on the testing of nonylphenol for oncogenicity, genotoxicity, or teratogenicity/reproductive effects.

C. Environmental Effects

Nonylphenol was found to be very toxic to all aquatic organisms studied, with EC₅₀ and LC₅₀ values ranging from 0.13 to 5.0 mg/L. The two bivalves studied, a nonmotile alga, and the freshwater ide appear to be the most resistant to nonylphenol toxicity, with all other organisms tested exhibiting LC₅₀ values below 1.0 mg/L. Adverse behavioral effects and swollen bodies with hemorrhaged areas have been observed in fish undergoing acute toxicity testing.

The uptake and excretion of 4-nonylphenol and nonylphenol were studied in two saltwater species. The uptake of 4-nonylphenol in Salmo salar increased rapidly for the first two days of exposure (mean nonequilibrium bioconcentration factor about 200), and then decreased by one order of magnitude after 4 days. Excretion was almost complete four days following exposure. In the mussel, Mytilus edulis, maximum concentrations were found to occur at 0.4 days, with an estimated half-time for clearance of 0.3 days. No other data on metabolism in aquatic organisms was found.

Nonylphenol was found to depress the growth rate of cultures of Chlorella pyrenoidosa at 0.025 µg/mL, and to kill 100% of the cells at 25 µg/mL. In the same study, nonylphenol was found to produce ultrastructural changes in the cell walls, and distort the flagellae of Chlamydomonas reinhardtii.

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Nonylphenol

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I. Summary of Available Data

Technical grade nonylphenol is a mixture of monoalkyl phenols, predominantly para-substituted (Hawley 1981). The substitutions occur with various isomeric branched-chain nonyl groups (Reed 1978). The isomer or mixture used in studies reported in the literature is not always specified. In this report, nonylphenol (mixed isomers) and the unidentified isomers will be discussed as nonylphenol, and when identified as such in the literature, the particular isomer (4- or 2-nonylphenol) will be indicated.

A. Chemical Identity

The chemical identities of nonylphenol (mixed isomers), 4-nonylphenol, and 2-nonylphenol are listed in Table 1.

B. Physical and Chemical Properties

Nonylphenol is a viscous liquid, pale yellow in color, with a slightly phenolic odor (Hawley 1981). Dietz and Traud (1978) list an odor threshold of 1000 µg/L for p-nonylphenol. The physical and chemical properties of nonylphenol (mixed isomers), 4-nonylphenol, and 2-nonylphenol are listed in Table 1.

C. Exposure

1. Worker Exposure

a. Production/Importation

Estimated production of nonylphenol for 1982 was 140 million pounds (SRI 1984, as reported in USEPA 1985a). Consumption is expected to increase to 165 million pounds by 1987 (Mannsville 1982, as reported in USEPA 1985a).

A review of the production range (includes importation volumes) statistics for 4-nonylphenol (CAS No. 104-40-5) and nonylphenol, mixed isomers (CAS No. 25154-52-3) which are listed in the initial TSCA Inventory (USEPA 1983), has shown that between 3 and 30 million pounds of 4-nonylphenol and between 11 and 60 million pounds of nonylphenol (mixed isomers) were reported as produced/imported in 1977. SCI (1985) reports that approximately 18 million pounds of 4-nonylphenol were manufactured in 1984 for sale and internal use.

A review of the production range (includes importation volumes) statistics for 2-nonylphenol (CAS No. 136-83-4) which are listed in the initial TSCA Inventory (USEPA 1983), has shown that no 1977 production/importation was reported or that all of the production range data reported were claimed as

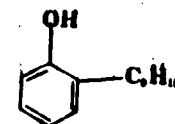
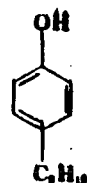
* This production range information does not include any production/importation data claimed as confidential by the person(s) reporting for the TSCA Inventory, nor does it include any information which would compromise Confidential Business Information. The data submitted for the TSCA Inventory, including production range information, are subject to the limitations contained in the Inventory Reporting Regulations (40 CFR 710).

Table 1. Chemical Identity and Physical and Chemical Properties of Nonylphenol

A. Chemical Identity

1. CAS Registry Number:	25154-52-3	104-40-3	136-83-4
2. Chemical Name:	Phenol, nonyl- (8CI)(9CI)	Phenol, 4-nonyl- (9CI)	Phenol, 2-nonyl- (9CI)
3. Synonyms:	Nonyl phenol (mixed isomers); Nonyl-phenol; Prevostsol Von-100; 2,6-Dimethyl-4-heptylphenol (o and p)s; Hydroxy No. 253b	p-Nonylphenol; Phenol, p-nonyl-(8CI); 4-Nonylphenols	Phenol, o-nonyl- (8CI)s

4. Structural Formula:



Molecular formula:

$C_{15}H_{24}O$

$C_{15}H_{24}O$

$C_{15}H_{24}O$

B. Physical and Chemical Properties

1. Molecular Weight:	220.3	220.3	220.3
2. Physical State:	Clear, straw-colored viscous liquidb		
3. Freezing Point (°C):	-10°	-10d	
4. Boiling Point (°C):	295-320 (at 101.3 kPa)e	289-306d	
5. Solubilities in			
(a) Water	Slightly solubleb; 5 mg/L at 20-25°Cf; Slightly soluble in dilute aqueous NaOHg	Slightly soluble in hot or cold water and aqueous alkali solutionsh	
(b) Non-aqueous solvent	Soluble in benzene, chlorinated sol- vents, aniline, heptane, aliphatic alcohol, ethylene glycolb		
6. Dissociation Constant:	Not Found	Not Found	Not Found
7. Partition Coefficient (log P) (Octanol/Water):	4.10f		
8. Density (g/cm³):	0.949 ^{20b} ₄		
9. Volatility:	Vapor pressure - 23 mm Hg (181°C)s		

Table 1. (Continued) Physical & Chemical Properties of Nonylphenol

10. Other

a. Refractive index (n_D^{20}):	1.513 ^h
b. Vapor density: (air=1)	7.39 ^b
c. Flash point (open cup):	141°C (285°F) ^d
d. Pour point:	2°C ^b
e. Viscosity:	363 cp (20°C) ^c
f. Critical temperature:	470°C ⁱ
g. Liquid surface tension (est.):	30 dynes/cm ⁱ
h. Liquid-water interfacial tension (est.):	30 dynes/cm ⁱ
i. Heat of combustion (est):	-17,500 BTU/lb ⁱ

11. Reactivity of Nonylphenol

In alkylphenols, the presence of 2- and 4- alkyl groups generally precludes further reaction at those positions. Remaining vacant ortho and para positions are available for electrophilic substitutions such as chlorination, bromination, sulfonation, and nitration. Of commercial application is the etherification of nonylphenol with ethylene oxide using a basic catalyst to form nonionic surfactants of the nonylphenol ethoxyate type^e. May form CO or CO₂ in limited air supply^j.

^aMSLARS(CHEMLINE) 1983

^bBAx 1984

^cHawley 1981

^dLowenheim and Moran 1973

^eReed 1978

^fZitko and McLeese 1980, as reported in Geyer et al. 1982

^gTanker Safety Guide 1971, as reported in Hann and Jenson 1974

^hWindholz et al. 1983

ⁱWeiss 1980

^jTexaco 1985a

confidential by the manufacturer(s) and/or importers and cannot be disclosed (Section 14(a) of the TSCA, U.S.C. 2613(a)).

b. Producers/ Importers

Domestic producers of 4-nonylphenol and nonylphenol (mixed isomers) for 1977, their addresses, and the reported production, as listed in the public, non-confidential portion of the TSCA Inventory, are given in Table 2 and 3, respectively. One unidentified manufacturer for 2-nonylphenol is listed in USEPA (1983), with the plant site not on file, and production volume not reported for 1977.

Nonylphenol is currently manufactured by 10 companies at 13 sites in the United States, with limited or no importation of nonylphenol occurring. Less than 10% of the current market is exported (SRI 1984, as reported in USEPA 1985a). Table 4 lists the location and production capacity of each of the plants. Listed capacity is principally that of nonylphenol and dodecylphenol, although other alkylphenols are generally produced with the same equipment (USEPA 1985a). SCI (1985) reports that they manufactured approximately 18 million pounds of nonylphenol in 1984 for sale and internal use.

c. Production Methods

Industrial manufacture of nonylphenol is by liquid-phase alkylation of phenol with mixed isomeric nonenes (propylene trimer) in the presence of an acid catalyst. This catalyst may be sulfuric acid, aluminum trichloride, or boron trifluoride. Material requirements for a yield of one metric ton of 4-nonylphenol are 620 kg phenol, 450 kg nonene, and a small amount of catalyst. Premixed phenol and nonene are fed to an agitated, jacketed tank reactor where they react at 50 to 100° C for 30 to 120 min, and yield a mixture of isomers, mostly para-, with some ortho- and 2,4-dinonyl substitution (Lowenheim and Moran 1975). The crude product is washed several times and heated under vacuum to remove traces of reactants and water. In the final step, nonylphenol is separated by vacuum distillation at 10 to 20 mm Hg. Nonylphenol is recovered at the top of the distillation column, stored, or shipped in 55 gallon drums or tank cars. Dinonylphenols are recovered as bottoms (USEPA 1985a). The yield of nonylphenol is about 75-80%, and the yield of dinonylphenol is about 10-20% (Lowenheim and Moran 1975).

d. Industrial/Occupational Uses

The principle use of nonylphenol is as an intermediate in the production of nonionic ethoxylated surfactants. About 70% of the nonylphenol produced is used in this fashion (Lowenheim and Moran 1975), and nonylphenol ethoxylate is the dominant alkylphenol ethoxylate surfactant (USEPA 1985a). However, this use is not expected to expand in the United States as nonylphenol-derived detergents have poor biodegradability, and are not used in household cleansers. In Europe they are still used in cleansers (Lowenheim and Moran 1975).

* The data submitted for the TSCA Inventory including production range information, are subject to the limitations contained in the Inventory Reporting Regulations (40 CFR 710).

Table 2. 1977 Production of 4-Nonylphenol

Company	Production ^a
Ferro Corp. Productol Chem. Div. 10051 Romandel Ave. Santa Fe Springs, CA	NR ^b
Uniroyal, Inc. Uniroyal Chem. Div. Elm Street Naugatuck, CT	1-10
Schenectady Chem., Inc. Route 5S Rotterdam Jct, NY	1-10
Schenectady Chem., Inc. P.O. Box 2830 Freeport, TX	1-10
GAF Corporation P.O. Box 12 Linden, NY	NR
GAF Corporation P.O. Box 37 Calvert City, KY	NR

^aMillions of pounds.^bNot reported.

Source: USEPA 1983a.

Table 3. 1977 Production of Nonylphenol (Mixed Isomers)

Company	Production ^a
Union Carbide Corp. River Road Bound Brook, NJ	NR ^b
Borg-Warner Chem. P.O. Box 816 Morgantown, WV	NR
Montedison USA ^c 1114 Ave. of the Americas New York, NY	None
Rohm & Haas 5000 Richmond St. Philadelphia, PA	NR
Rohm & Haas P.O. Box 672 Deer Park, TX	NR
Continental Oil Co. 191 Doremus Ave. Newark, NJ	None
Henley & Co., Inc. ^c 750 third Ave. New York, NY	NR
Filo Chem. Corp. ^c 347 Madison Ave. New York, NY	None
Monsanto Company Pennsylvania Ave. Kearny, NJ	10-50
Kalama Chem., Inc. 1296 N.W. 3rd St. Kalama, WA	1-10
Jefferson Chem. Co. P.O. Box 847 Port Neches, TX	NR
Ferro Corp. Productol Che. Div. 10051 Romandel Ave. Santa Fe Springs, CA	NR

^aMillions of pounds.^bNot reported.^cImporters.

Source: USEPA 1983a.

Table 4. Plant Capacity for U.S. Producers of Nonylphenol^{a,b,c}

Company	Location	Capacity (million lb)
Standard Oil of CA	Belle Chasse, LA	86
Schenectady	Oyster Creek, TX	75
Borg-Warner	Morgantown, WV	60
Monsanto	Kearny, NY	45
Exxon	Bayway, NJ	40 ^d
Rohm & Haas	Deer Park, TX	40
Rohm & Haas	Philadelphia, PA	40
Texaco	Port Neches, TX	35
Schenectady	Rotterdam Jct, NY	25
GAF	Linden, NJ	20
Kalama	Kalama, WA	20
GAF	Calvert City, KY	15
Uniroyal	Naugatuck, CT	10 ^d

^aUSEPA 1985.^bAs of January 1983.^cIncludes production of dodecylphenol and other alkylphenols.^dCaptive use.

In producing these surfactants, nonylphenol is reacted, generally in a batch process, with ethylene oxide in the presence of a basic catalyst, to yield ethoxylates of various polyethylene oxide chain lengths (USEPA 1985a). By changing the moles of ethylene oxide, the use and solubility of the surfactant changes (the water solubility increases as chain length increases). Emulsifiers for grease and oil are produced with 4 to 6 moles of ethylene oxide per molecule of nonylphenol, laundry detergents with 7 to 11 moles, emulsifiers for solvents and pesticides with 13 to 15 moles, and emulsion polymerization of latex is achieved with 30 to 40 moles of ethylene oxide (USEPA 1985a). The 8 and 9 mole ethoxylates form the basis of high performance detergents, particularly for textile scouring, but they have been replaced by straight chain C_{12} - C_{14} alcohol ethoxylates in household detergents (Reed 1978).

Fifteen companies produce these alkylphenol ethoxylate surfactants, using about 97.5 to 112.5 million pounds of nonylphenol, for use primarily as industrial or agricultural cleansers (USEPA 1985a). Due to their lack of sudsing ability, these surfactants are rarely used as laundry detergents or as consumer products, however, an increase in its use has appeared in private label and generic household cleaning products (USEPA 1985a).

Alkylphenol ethoxylate surfactants are produced by GAF, Monsanto, Rohm & Haas, Texaco, Union Carbide, BASF, Diamond Shamrock, ICI Americas, Milliken, Millmaster Onyx, M & T Chemicals, National Distillers, Stephan, Thompson-Hayward, and Witco (SRI 1983, as reported in USEPA 1985a).

The second largest use of nonylphenol is in the plastics and rubber industry, where it is used as an intermediate in the manufacture of phosphite antioxidants. Approximately 15% of the nonylphenol produced was used for this purpose in 1975 (Lowenheim and Moran 1975). The principle use of nonylphenol as a phosphite antioxidant is in the form of tris-4-nonylphenol phosphite (TNPP), produced by Borg-Wagner, GAF, and Olin Corporation (SRI 1983, as reported in USEPA 1985a). The TNPP is produced through esterification of nonylphenol in the presence of phosphoric acid, stored, then drummed in 55 gallon drums. Estimated production volume is 14 million pounds at the three sites (USEPA 1985a). TNPP is used principally as a liquid stabilizer system for polyvinyl chloride resins, and secondly as an antistaining antioxidant for other plastics and elastomers. Phosphites have been approved for indirect food use (SRI 1983, as reported in USEPA 1985a).

About 10% of the nonylphenol produced is reacted with formaldehyde to form compounds useful as oil additives and synthetic lubricants. The remaining use of nonylphenol (5%) is as an intermediate in the manufacture of polyvinyl chloride plasticizers, in pharmaceuticals, and as corrosion inhibitors (Lowenheim and Moran 1975).

Nonylphenol by itself does not appear to have any direct end uses (Reed 1978; SCI 1985) although one significant application is in an admixture with diisobutyl phthalate for marking fuel oil for taxation purposes (Reed 1978). Nonylphenol is labelled as a major inert component (50.5%, acting as a surfactant) of the pesticide, Natacil 1.8-D, used in controlling spruce budworm in eastern Canada (Sundaram et al. 1980). Although not confirmed by other reference sources, Weinberger and Rea (1982) state that nonylphenol is a

widely used constituent of paints, inks, and shampoos, and Rantuccio et al. (1984) note that nonylphenol is used in cosmetics.

e. Detection Methods

Nonylphenols are not detectable by the standard methods used for the collective determination of nonionic surfactants (Giger et al. 1981). High resolution gas chromatography has been successfully used to separate technical grade 4-nonylphenol into nine major peaks identified as para-substituted compounds as well as a minor amount of ortho-substituted compounds. Nonylphenols can also be identified by their fragmentation patterns with mass spectrometry.

Anstern et al. (1975) devised a method of detecting low levels of nonylphenol in wastewater. This method includes extraction with freon, concentration of the extract in a Kjederna-Danish apparatus, and gas chromatography with a hydrogen flame detector. Recovery from spiked raw and treated wastewaters was $99.9 \pm 3.5\%$, with the minimum detectable quantity being 2.2 ng.

f. Worker Exposure

No data are available regarding worker exposure to nonylphenol during its manufacture. However, worker exposure scenarios have been developed, based on models presented by USEPA (1984, as reported in USEPA 1985a), utilizing parameters such as vapor pressure, form of the material, and concentration of the material. Since the preparation of nonylphenol takes place in a closed reactor system, there is not likely to be any occupational exposure during this step in its manufacture. There is, however, a potential for exposure to nonylphenol during the activities of sampling and loading the product (Monsanto 1985a). The USEPA (1985a) estimates that up to 4 workers/site could be exposed in this fashion for up to 4 hr/day for 250 days/year. If the workers wear gloves, dermal exposure would be low. Due to the low vapor pressure of nonylphenol, inhalation exposures are expected to be negligible (USEPA 1985a).

Occupational exposure during the production of nonylphenol ethoxylates and phosphite antioxidants will be similar, although the latter will be produced at only three sites. Potential exposure may occur while undrumming and charging the nonylphenol to the reactor, and during sampling activities. USEPA (1985a) estimates that up to 4 workers/site would be exposed for less than 1 hr/day during these activities, for about 330 days/year. Dermal exposure would remain low if protective gloves are worn, but would be similar to that during manufacture if gloves are not worn. Inhalation exposure would again be negligible (USEPA 1985a).

SCI (1985) state that in 10 years of making, handling, and using nonylphenol, no employee exposure problems attributable to nonylphenol have been experienced.

Ikeda et al. (1970) suggest the possibility that a certain portion of nonylphenol used to produce nonionic surfactants used in detergents might remain unreacted, and appear as a contaminant in the final detergent product. They also suggest the possibility that the polyoxyethylene alkylphenylethers used in the detergents may decompose to yield free alkylphenol.

2. Consumer Exposure

Consumers might be exposed to nonylphenol during the handling and use of various products to which it is reportedly added. These include cosmetics (Rantuccio et al. 1984, Weinburger and Rea 1982), the pesticide Matacil (Sundaram et al. 1980), and paints and inks (Weinburger and Rea 1982).

Only one study was found which measured consumer exposure to nonylphenol isomers (Weschler 1984). Indoor-outdoor measurements of nonpolar organic constituents of aerosol particles were made in two office buildings. Average indoor concentrations of nonylphenol isomers were 15 and 30 ng/m³, whereas associated outdoor measurements of nonylphenol were not detected. The author could not identify the actual source of the isomers in either of the offices sampled.

3. Environmental Exposure

a. Environmental Release

Limited information on environmental releases of nonylphenol during manufacture or use was located. Table 5 lists levels of nonylphenol which have been measured in wastewater effluents or untreated waste from various manufacturing facilities. Garrison and Hill (1972) reported concentrations of p-nonylphenol in wastes and receiving waters from a carpet yarn mill (Table 5). The authors found an eighty-fold increase in the concentration of 4-nonylphenol between the treatment pond influent and effluent, which they attributed to the possible anaerobic biodegradation of a nonionic surfactant used in the washing and drying processes. Shackelford et al. (1983) detected 4-nonylphenol in 11 water samples associated with various industrial sources (Table 6), at concentrations ranging from 2 to 1,620 µg/L.

Borg-Warner (1985) reports µg/L levels for 4-nonylphenol in effluent discharges into the Monongahela River. However, since the effluent is discharged into the river at a rate of 200 to 450 gal/min, with river flow averaging 4390 ft³/sec, Borg-Warner (1985) indicate that the effluent is substantially diluted. Several other studies have identified nonylphenol in secondary effluents from municipal treatment plants (Ellis et al. 1982), or in rivers receiving wastewaters from various chemical industries (Moore and Karasak 1984). Quantitative determinations were not made in these studies.

Releases of nonylphenol to the environment during the manufacture of nonionic surfactants will probably occur during the disposal of used nonylphenol drums, and the cleaning of equipment (USEPA 1985a). Used nonylphenol drums will probably be landfilled or incinerated. There are no estimates of the quantities of nonylphenol that might be released during these processes (USEPA 1985a).

Table 5. Levels of Nonylphenol in Wastewater Effluents

Level	Source	Sample	Reference
13 ng/L ^a	Unknown	AWT ^b Municipal sewage	Lin et al. 1981
10-35 µg/L	Sewage treatment plants	Secondary effluent	Stephanou and Giger 1982
0.05 mg/L	Specialty chemical plant	Wastewater effluent	Hites et al. 1979
0.05 mg/L	Carpet yarn mill	Untreated waste	Garrison and Hill 1972
0.06 mg/L	Tire manufacturing plant	Wastewater effluent	Jungclauss et al. 1976
4.0 mg/L (4-nonylphenol)	Carpet yarn mill	Treatment pond effluent	Garrison and Hill 1972

^aApproximate concentration.

^b AWT = Advanced waste treatment water.

Table 6. Occurrence of 4-Nonylphenol in Environmental Samples ($\mu\text{g/L}$)

Industry	Frequency	High Conc.	Median Conc.	Low Conc.
Nonferrous metals	8	120	48	10
Paint and Ink	2	79	44	8
Organics and Plastics	9	469	132	8
Inorganic chemicals	3	3	2	2
Rubber processing	1	1617	1617	1617
Auto and other laundries	2	270	242	214
Aluminum	3	13	11	7
Organic chemicals	4	109	91	36
Public-owned treatment works	11	51	4	2
NA	1	45	45	45
Industry unknown	2	32	26	20

^aNA = not available.

Source: Shackelford et al. 1983.

Releases of nonylphenol during the manufacture of phosphite antioxidant intermediates are expected to be low. Losses that might occur from storage drums or equipment cleaning would be to landfill (USEPA 1985).

b. Environmental Fate

i. Persistence

(a) Biodegradation

Fischer et al. (1974, as reported in CHEMEATE 1985) studied the biodegradation of nonylphenol in a closed bottle test for BOD. Two ppm nonylphenol was tested at 20°C with sampling at 0, 5, 15, and 30 days. Zero to 3% BOD removal was observed, indicating little or no degradation.

Gaffney (1976) reported no degradation of 1 mg/L nonylphenol after 135 hr in domestic wastewater, or after 24 hr in industrial wastewater, but he found 45% degradation of the nonylphenol after 135 hr incubation in the industrial wastewater.

Sundaram and Szeto (1981) studied the dissipation of nonylphenol in stream and pond water when incubated in open and closed flasks. They found no transformation products after open incubation, but an unidentified transformation product(s) was detected via HPLC in both pond and stream water after 3 days incubation in the closed system. Photo-oxidation or microbial hydroxylation were suggested as the possible mechanism of transformation. In the same study the authors found that nonylphenol was rapidly dissipated from pond water in the presence of sediment, with about 50% of the nonylphenol appearing in sediment after 10 days, and the remainder undetected in water or sediment. About 80% of the nonylphenol translocated to the sediment was degraded in 70 days, with no degradation occurring in autoclaved water and sediment samples.

4-Alkylphenol polyethoxylate surfactants are biodegraded during aerobic treatment of wastewater by activated sludge to yield 4-alkylphenol mono- and diethoxylates. Giger et al. (1984) postulate that high levels of 4-nonylphenol measured in stabilized sewage sludge originate from the alkylphenol ethoxylates. Giger et al. (1984) suggest that the 4-alkylphenol mono- and diethoxylates formed during microbial anaerobic degradation of the alkylphenol polyethoxylate surfactants are less biodegradable, and less water-soluble, and are partially removed from wastewater by sorption to lipophilic flocs of sludge. To test their hypothesis that anaerobic environments favor the accumulation of 4-nonylphenol, Giger et al. (1984) conducted controlled batch experiments with raw and anaerobically stabilized sludge and observed a 4- to 8-fold increase in the concentration of 4-nonylphenol in the stabilized sludge relative to that originally present in the raw sludge. Batch experiments involving aerobic incubation resulted in increases in 4-nonylphenol concentration by only a factor of two.

(b) Photodegradation

No information regarding the photodegradation of nonylphenol and its isomers was found.

(c) Hydrolysis

No information regarding the hydrolysis of nonylphenol and its isomers was found.

(d) Other routes of degradation

No other information regarding the environmental fate of nonylphenol and its isomers was found.

(e) Bioaccumulation

Although the log P of nonylphenol (4.10) suggests that bioaccumulation may occur, the study of McLeese et al. (1980a) indicates a low bioaccumulation of nonylphenol in the saltwater mussel, Mytilus edulis. Mussels with valve lengths of about 5.0 cm were exposed for four days in static tests at 15°C to nonylphenol at nominal concentrations of 0.1 and 1.13 mg/L. Nonylphenol in the mussels reached a maximum concentration between one and two days, and decreased by four days. Estimated bioconcentration factors (BCF) ranged from 1.4-13. The authors conclude that due to the low calculated bioconcentration coefficient (uptake/excretion), nonylphenol concentrations in seawater of less than 0.01 mg/L are not likely to result in significant accumulation in mussels.

Kawasaki (1980) reports a bioconcentration factor of about 100 for nonylphenol isomers, while Sasaki (1978) listed it as a chemical known to have little or no bioaccumulation.

ii. Transport

(a) Air

No data were found.

(b) Water

Hites et al. (1979) measured levels of nonylphenol in treated wastewater from a specialty chemicals plant which manufactured many products, including surfactants. Samples were also taken at various stations up- and downstream from the point where the wastestream entered a river, and in river sediment. Levels of 0.05 ppm nonylphenol were measured in the wastewater, but no nonylphenol was detected in either river water or sediment samples.

Table 7 lists measurements of nonylphenol in receiving waters downstream from a carpet yarn mill (Garrison and Hill 1972). The rapid dissolution of nonylphenol as it moved downstream from the discharge point indicates dilution by the water body.

Table 7. Concentration of 4-Nonylphenol in Textile Waste and Receiving Waters

Sample Location	Concentration (mg/L)
Plant total untreated waste	0.05
Treatment pond effluent	4.0
Small creek (1 mi) ^a	3.0
Small river (1.5 mi) ^a	0.2
Small river (4.5 mi) ^a	0.03
Savannah River (6 mi) ^a	0.002

^aDistance below pond discharge.

Source: Garrison and Hill 1972.

In order to study the fate and persistence of nonylphenol under field conditions, Sundaram et al. (1980) applied 0.47 L nonylphenol/ha (equivalent to the seasonal allowable maximum of Mataril formulations containing nonylphenol) aerially to a mixed coniferous forest. Nonylphenol was detected in water from a treated stream immediately following application, and persisted for 5 days. The highest concentration of nonylphenol detected was 9.1 ppb one hour after spraying, which decreased to <2.0 ppb in 6 hr, and was not detected at 24 hr. Under the field conditions tested, the estimated half-life of nonylphenol was about 2.5 hr. The authors assume that the rapid dissipation of nonylphenol residues in stream water was due to dilution by water flow. Other factors which could have contributed to dissipation were suggested as surface evaporation, and codistillation. Nonylphenol was detected in only one stream sediment sample (less than 0.10 ppm) four hours following application, indicating to the authors that diffusion of nonylphenol downward in the water column would be minimal.

Ernst et al. (1980) found nonylphenol to disappear rapidly from aqueous solution in open tanks, with up to a 90% loss occurring within 48 hr. The apparent correlation of nonylphenol disappearance with surface area/volume ratios, aeration, and stirring, suggests that volatilization is the primary route of dissipation.

Sundaram and Szeto (1981) studied the behavior of nonylphenol in static aquatic environments using open and closed systems. They found that nonylphenol dissipated in spiked samples of both pond and stream water in open flasks with a half-life of 2.5 days. Persistence in closed systems was longer, with a half-life of 16.5 and 16.3 days estimated for stream and pond water, respectively. The authors feel that these findings support the conclusion that dissipation of nonylphenol in aquatic systems results from surface volatilization and codistillation.

(c) Soil

Kingsbury et al. (1981) applied nonylphenol to terrestrial ecosystems at a rate equivalent to the quantity of nonylphenol applied in allowable maximum seasonal sprayings of Mataril. They were unable to detect nonylphenol in soil samples from a study plot well exposed to the aerial deposition of nonylphenol. They suggest that nonylphenol disappears very rapidly from soil via physical, chemical, or biological processes.

(d) Biota

In the study by Sundaram et al. (1980) nonylphenol residue in white spruce foliage reached its highest concentration (18.9 ppm) one hour after spraying with nonylphenol. Residues declined steadily, and were undetectable after 62 days, with a half-life of 2.8 hr. Quantities of nonylphenol on the forest floor, if present, were below the levels of detection, indicating a filtering effect from the foliage (Sundaram et al. 1980).

c. Environmental Occurrence

A few measurements of nonylphenol in rivers or tributaries exist in the literature, and these are summarized in Table 8. Measured values range from

Table 8. Environmental Levels of Nonylphenol

Level	Source	Sample	Reference
1-2 ppb (winter)	Unknown	Delaware R., Philadelphia, PA	Hites et al. 1979
0.04-1 ppb (summer)	Unknown	Delaware R., Philadelphia, PA	Hites et al. 1979
325 ppb (4-nonylphenol)	Unknown	Lower Tennessee R., below Calvert City, KY	Goodley and Gordon 1976, as reported in CHEMFATE 1983
0.5-2.0 µg/L	10 municipal treatment plants	Glatt R., Switzerland	Ahel et al. 1983
1.0 mg/L	Wool scouring plant	Savannah R. tributary	Gustafson 1970, as reported in Garrison and Hill 1972

^aApproximate concentration

40 ng/L to 1 mg/L. Holmes and Kingsbury (1980, as reported in Moody et al. 1983) found levels of nonylphenol up to 1.1 ppm in stagnant water following an operational pesticide spray program in Ontario.

D. Health Effects

1. Metabolism

One pharmacokinetics study exists (Khask et al. 1966) describing the excretion of ^{14}C -nonylphenol when administered orally or intraperitoneally to 150 g male rats (Farms-Elias stock). Daily urine and fecal samples were collected and analyzed for a period of 7 days, and CO_2 samples were collected and analyzed for 4 days. By day 4 of the 7-day sampling period, the majority of the labelled nonylphenol was excreted in urine (19%), and feces (70%). No radiolabelled CO_2 was detected. Identical results were obtained with both methods of administration. First-day urine samples were analyzed with ion exchange chromatography, and 25% of the urinary metabolites of ^{14}C -nonylphenol chromatographed as neutrals. The remaining ^{14}C chromatographed as acids after the neutrals, and were believed to be mainly glucuronic acid conjugates (75%) of nonylphenol.

2. Lethality

Smyth et al. (1962, 1969) report for the mixed isomers an oral ID_{50} for rats of 1.62 mL/kg (1537 mg/kg based on a density of 0.949 g/cm³) and a dermal ID_{50} for rabbits of 2.14 mL/kg (2031 mg/kg based on a density of 0.949 g/cm³). They list 4 hr as the maximum time to death for rats inhaling a concentrated vapor. Texaco (1985a) and Monsanto (1985b) list an oral ID_{50} for rats of 0.58 g/kg, and 1300 mg/kg, respectively. Monsanto (1985b) lists a dermal ID_{50} for rabbits of >2000 mg/kg and <3160 mg/kg.

3. Oncogenicity

No information.

4. Genotoxicity

No information.

5. Teratogenicity/Reproductive Effects

No information.

6. Other Effects

a. Skin and Eye Effects

Nonylphenol caused necrosis (graded 6 on a scale of 1-10) when applied at a strength of 10 mg/24 hr to shaved rabbit skin. It caused severe corneal damage (graded 10 on a scale of 1-10) as a 1% solution applied (0.5 mL) to rabbit eyes (Smyth et al. 1962, 1969). Nonylphenol produced moderate

irritation when 500 mg was applied to rabbit skin (UDS 1959, as reported in Sax 1984).

Rantuccio et al. (1984) studied the irritant potential of nonylphenol when massaged into shaved rabbit skin daily for 30 days. A 10% solution of nonylphenol in water (0.5 mL/day) was found to give rise to increased layers of epidermal cells and increased cells in the superficial dermis. The absolute fibroblast count was raised 52% although the relative count was not raised. The basement membrane was unaltered and the fibers of the dermis showed no gross changes. Elastic fibers had almost disappeared. Although nonylphenol induced changes in the form of increased numbers of epithelial cell layers, and dermal cell count, the authors note the difficulty in evaluating the results, and in extrapolating them to human tissues.

Texaco (1985b) applied 0.5 mL nonylphenol directly to the shaved skin of one male and one female rabbit. The material remained in contact with the skin for 4 hr, and skin necrosis was visible in both rabbits at 48 hr after the application. Texaco (1985a) and Monsanto (1985b) list a skin irritation index (based on the Draize Method) for nonylphenol of 8.0/8.0 and an eye irritation index of 57/110 and 58/110, respectively, for rabbits. Nonylphenol is listed as a corrosive agent which may cause burns and blistering to the skin. It is extremely irritating to the eyes, and may cause permanent eye injury (Texaco 1985a).

The acute toxicity of 20 compounds used by the Air Force was studied to establish safe handling guidelines (Gaworski et al. 1979, as reported in MEDLARS II [TOXBACK76] 1985). Nonylphenol was reported to cause a skin sensitization reaction in 18 of 20 animals dosed (level of dosing and type of animals tested not given in abstract).

Texaco (1985c) tested nonylphenol for skin sensitization using ten male albino guinea pigs and a modified Buehler test method. Under the conditions of the study, no skin sensitization was observed.

Weiss (1980) states that nonylphenol causes smarting of the skin and first-degree burns on short exposure, and may cause secondary burns on prolonged exposure. The vapors cause a slight, temporary, smarting of the eyes or respiratory system if present in high concentrations.

Gellin et al. (1979) tested the depigmenting capacity of various phenols, including nonylphenol, using black guinea pigs and black adult mice (strains not given). They report that irritation was observed with all phenols, but that nonylphenol did not induce depigmentation.

b. Biochemical Effects

The partitioning and interfacial interaction of ^3H -adenosine triphosphate to various amphiphiles (lipophilic groups attached to amino acid residues) has been studied by Hideshima et al. (1977). It was found that 4-nonylphenol did not directly react with nucleotides, probably due to electrostatic repulsion. In the presence of Ca^{2+} , interaction did occur, although Mg^{2+} did not enhance nucleotide interaction with nonylphenol.

7. Case Reports and Epidemiological Studies

In a case report, Sherman (1985) describes multiple birth defects in a 3-week old male infant. The mother was exposed to a polymeric material applied with a nonylphenolic ethoxylated surfactant during the early part of her pregnancy.

Ikeda et al. (1970) reported two cases of leucoderma in women engaged in degreasing metal parts with synthetic detergents containing polyoxyethylene (3 to 16) nonyl- or octylphenylether. Analysis of the detergents revealed contamination with free alkylphenol, possibly nonylphenol or octylphenol, and the authors suspected that the leucoderma was caused by the free alkylphenols. They hypothesized that either a certain portion of the alkylphenols added as a starting material to form the detergents remained unreacted, or decomposition of the detergents during their use yielded free alkylphenols. No positive correlation between the cases of leucoderma and nonyl- or octylphenol were made. No other case reports or epidemiological studies were found specifically dealing with nonylphenol.

E. Environmental Effects

1. Metabolism

Uptake (K1) and excretion (K2) rate constants, time to maximum concentration, and half-time for clearance of nonylphenol in the saltwater mussel, Mytilus edulis, were estimated by McLeese et al. (1980a). Mussels were exposed for four days in static tests at 15°C to nonylphenol concentrations of 0.1 and 1.13 mg/L of sea water. Maximum concentrations occurred at 0.4 days, with a K1 of 23/day, a K2 of 2.3/day, and a half-time for clearance of 0.3 days.

In a static test, McLeese et al. (1981) studied the uptake and excretion of p-nonylphenol in Atlantic salmon (Salmo salar) that were placed for four days in water containing p-nonylphenol and then transferred to clean water. On the first day of exposure, the concentration of nonylphenol in the water was 0.31 mg/L and the average tissue concentration (uptake) for two fish was 72.7 µg/g of tissue (wet weight). On day 4, the concentrations had dropped to 0.17 mg/L in the water and 12.7 µg/g of tissue in the fish. The excretion of p-nonylphenol, evaluated on the basis of tissue measurements that were made after the fish had been placed in clean water, was almost complete by four days. At that time, the average tissue concentration of nonylphenol had dropped to 0.48 µg/g. No other data on metabolism in aquatic organisms were found.

2. Lethality

Lethality data for freshwater and saltwater species are listed in Table 9. It can be seen that nonylphenol is very toxic to all organisms studied, with a range of LC₅₀ values from 0.13 to 5.0 mg/L. The two bivalves studied (Anodonta and Mya) were relatively resistant to nonylphenol toxicity. Bringmann and Kuhn (1982) report an EC₅₀ value (based on immobilization) of 0.18 mg/L for Daphnia magna. In contrast to this, Monsanto (1985a) lists a

Table 9. Lethality of Nonylphenol in Environmental Species

Species	LC50	Dose (mg/L)	Conditions	Reference
<u>FRESHWATER</u>				
Fathead minnow (<i>Pimephales promelas</i>)	96 hr	0.135	FT ^a	Holcombe et al. 1984
	96 hr	0.3	NA ^b	Monsanto 1985b
Rainbow trout (<i>Salmo gairdneri</i>)	96 hr ^c	0.23	NA	McLeese et al. 1980b
	96 hr ^c	0.56-0.92	SD	Ernst et al. 1980
	24 hr ^e	0.484	S	Ernst et al. 1980
Brown trout (<i>Salvelinus fontinalis</i>)	96 hr ^c	0.145	NA	McLeese et al. 1980b
Ido (<i>Leuciscus idus</i>)	NA	1.3	NA	Knie et al. 1983
Freshwater clam (<i>Anodonta cataraetae</i>)	144 hr	5.0	S	McLeese et al. 1980b
Water flea (<i>Daphnia magna</i>)	24 hr	0.48	NA	Monsanto 1985a
	48 hr	0.44	NA	Monsanto 1985a
(<i>D. pulex</i>)	48 hr	0.14-0.19	S	Ernst et al. 1980
Nonmotile alga (<i>Chlorella pyrenoidosa</i>)	24 hr	1.5	S	Weinberger and Rea 1982
<u>SALTWATER</u>				
Atlantic salmon (<i>Salmo salar</i>)	96 hrf	0.13-0.19	FT	McLeese et al. 1981
	96 hrf	0.9	S	McLeese et al. 1980b
Sand shrimp (<i>Crangon septemspinosa</i>)	96 hr	0.30	S	McLeese et al. 1981
	96 hr	0.40	S	McLeese et al. 1980b
Lobster (<i>Homarus americanus</i>)	96 hr	0.20	S	McLeese et al. 1980b
Soft-shelled clam (<i>Mya arenaria</i>)	360 hr	>1.0	S	McLeese et al. 1980b

^aFT = flowthrough tests.^bNA = not available.^cFingerlings.^dS = static tests.^eEmbryos.^fJuveniles.

3. Reproduction

No data were found.

4. Behavior and Growth

Weinberger and Rea (1981) studied the ultrastructural effects of nonylphenol on a motile flagellate, Chlamydomonas reinhardtii. Chlamydomonas was exposed for 1 hr to 0.5 to 0.7 ppm nonylphenol added to the nutrient medium. Nonylphenol was found to distort the flagellae and to disrupt the ultrastructural architecture of the cell walls of treated cells.

Matacil 1.8D is a pesticide consisting of the carbamate aminocarb formulated with nonylphenol and a fuel oil distillate, 585 diluent oil. Weinberger and Rea (1981, 1982) exposed Chlorella populations to concentrations of aminocarb as high as 10 µg/mL and recorded growth stimulation, while the same concentration of formulated aminocarb in Matacil 1.8D proved lethal to Chlorella. Nonylphenol was added to Chlorella cultures at concentrations of 0, 0.025, 0.25, 2.5, 7.5, or 25 µg/mL. The average exponential growth rate was depressed at the four lower concentrations, while at 25 µg/mL, 100% kill was achieved. From these experiments a 24 hr LC_{50} of 1.5 µg/mL was estimated. Exposure of populations of Chlorella to diluent 585 oil concentrations as high as 15 µg/mL resulted in no population growth effects. The authors conclude that nonylphenol in the formulated pesticide, Matacil 1.8D, is responsible for the toxic effects seen in their algal growth studies.

Using the fluorometric determination of algal photosynthetic activity, nonylphenol was tested for its ability to inhibit photosynthesis in the green alga, Chlamydomonas reinhardtii after 1 hr of treatment (Moody et al. 1983). Inhibition of photosynthesis was 54.7% at 0.5 ppm nonylphenol, and 100% at 0.75 and 1.0 ppm. Equivalent concentrations of nonylphenol in the pesticide Matacil 1.8-D produced very similar results, while the carbamate Matacil and diluent 585 oil alone required concentrations of >100 and 30 ppm, respectively, to produce 100% inhibition of photosynthesis.

Six guppies and six snails (scientific names not given) were housed in natural lake water to which 0.5 ppm nonylphenol was added (Weinberger and Rea 1981). The behavior of the fish and snails was visually monitored. The guppies reacted immediately to the nonylphenol, showing an initial startle reaction, and later some slight disorientation, accompanied by less vigorous feeding. Two of the six guppies died within 24 hr, and the others recovered after 36 hr. The snails dropped from the inner surface of the tank and did not emerge for 8 hr. Following this, 5 of the snails returned to normal feeding behavior.

Holcombe et al. (1984) conducted flow-through acute toxicity tests with Pimephales promelas. Adverse behavioral effects were found in fish exposed to concentrations of nonylphenol greater than the LC_{50} (0.135 mg/L). At a concentration of 0.187 mg/L, surviving fish were lethargic, although still reacted to outside stimuli such as tapping the tank. At concentrations as low as 0.098 mg nonylphenol/L, some loss of equilibrium was observed in the fish.

Nonylphenol was found to significantly decrease (significant at the 1% level) percent seed germination in Jack pine (Pinus banksiana) and white birch (Betula papyrifera) at 100 ppm, and increase percent seed germination (significant at the 1% level) in white birch at 20 ppm (Weinberger and Vladut 1981). Water uptake was significantly reduced (significant at the 1% level) in Jack pine by 20 and 100 ppm nonylphenol (50 and 78% reduction, respectively). Length of sprouts of Jack pine seeds were decreased by 20% when treated with 100 ppm nonylphenol, and treated seeds gave rise to dwarfed seedlings. A five-fold reduction (81% decrease) in length of sprouts of white birch occurred following treatment with 20 ppm nonylphenol (the only level tested).

Arenically cultured fronds of Lemna minor were exposed to "ecologically relevant" concentrations of nonylphenol, aminocarb, 585 diluent oil, and the Matacil 1.8D formulation containing all three constituents (Weinberger and Iyengar 1983, as reported in MEDLARS II [MEDLINE] 1985). Frond growth, fresh and dry weight, chlorophyll content, photosynthesis, and total ATP content were significantly (level not reported) decreased by exposure to the Matacil 1.8D formulation, but not to aminocarb or 585 oil alone. The authors attributed the toxic effects to nonylphenol.

Knie et al. (1983) studied the effect of 4-nonylphenol on oxygen consumption in bacterial populations, and report an EC_{10} of >10 mg/L.

Lewis and Jurd (1972) studied the sporostatic activity of various phenolic compounds, including 4-nonylphenol, on Bacillus megaterium ATCC 10778. 4-Nonylphenol inhibited germination of B. megaterium in nutrient broth (99% inhibition at 2 hr) at 32 µg/mL, and prevented outgrowth at 10 µg/mL. A saturated solution of nonylphenol proved ineffective in inhibiting sporostatic activity after 24 hr incubation. Sporostasis was reversed by washing. Non-physiological (by-pass) germination was not inhibited. With 4-nonylphenol at 32 µg/mL, the lysis of 30 to 90% of the spores stopped with a phase-grey appearance, and the rest of the spores remained phase-bright. Based on the complete inhibition of sporostasis under good germination conditions at low concentrations, and the failure to block nonphysiological germination, the authors suggest that the sporostats studied reversibly render some proteins involved in physiological germination nonfunctional.

Torma and Itzkovitch (1976) studied the effects of nonylphenol on the oxygen uptake of the bacteria Thiobacillus ferrooxidans used in biohydrometallurgical treatment for metal recovery from low-grade sulfide-bearing materials. Surfactants may be adsorbed on the mineral surface during treatment, wetting the bacteria, and preventing intimate contact of the bacterium with the metal surface. They may also influence nutritive or growth processes by being adsorbed on the bacterial envelope or by changing the growth environment. Nonylphenol was found to reduce the surface tension of the reactive medium and the rate of oxygen consumption of T. ferrooxidans by approximately 40%.

5. Population Effects

Kingsbury et al. (1981) applied nonylphenol to terrestrial ecosystems at a rate equivalent to the quantity of nonylphenol applied in allowable maximum seasonal sprayings of Matacil. They found that nonylphenol did not have any

significant (level of significance not specified) effect on insect populations, forest songbird populations, or the ability of songbirds to defend their breeding territories.

6. Other Effects

Borg-Warner (1985) studied the factors affecting mortality in fathead minnows (Pimephales promelas) during 48-hr LC_{50} tests. Grab samples of effluent containing $\mu\text{g/L}$ concentrations of phenol, 4-nonylphenol and other nonylated isomers, tert-butylphenol, and multi-butylated phenols were used for the tests. The wastewater effluent tested is discharged into the Monongahela River.

Liver tissues from surviving fathead minnows exposed to either LC_{10} or LC_{50} levels of diluted effluent (the actual concentrations tested are not given) were studied using transmission electron microscopy. An increase in lipid droplets and nuclear aberrations was observed. Pathological observations included expanded rough endoplasmic reticulum, increased vacuolar and lysosomal population, and nuclear evagination and distortion. Increased concentrations of effluent resulted in increased cellular changes, indicating a dose-response relationship. Hyperplasia of gill tissue was also observed in surviving fathead minnows. Because the effluent consisted of a mixture of chemicals, the effects observed could not be attributed to any specific agent.

Holcombe et al. (1984) noticed hemorrhaged areas and bodies swollen with fluid in Pimephales promelas treated with 0.187 mg nonylphenol/L in acute flow-through tests.

Dizer et al. (1984) studied the effect of pollutants remaining in secondary and tertiary treatment waters on adsorption of viruses to sand, an excellent material for the adsorption of pathogenic viruses from contaminated waters. Experiments in the presence of nonylphenol seem to indicate that nonylphenol substantially diminished the adsorption of viruses by disrupting the hydrophobic bonds between the viruses and the substrate.

7. Abiotic Effects

No data were found.

F. Existing Standards, Regulations, and Recommendations

Proposed guidelines exist which limit nonylphenol effluent discharges into publicly owned treatment works (POTW) (USEPA 1985b). No other regulations regarding occupational, public, or aquatic exposure to nonylphenol or its isomers were found in the literature. A taste threshold of 0.001 mg/L for nonylphenol is given in Dawson et al. (1970, as reported in Anstern et al. 1975).

A red DOT shipping label is required for drums, tank cars and tank trucks containing nonylphenol (Lowenheim and Moran 1975).

II. References

A. Literature Cited

Note: Section 8(e) or FYI (For Your Information) submissions cited in this draft may be obtained by writing to "USEPA, Freedom of Information, Ms. Jerri Green (A-101), Washington, DC 20460." Submissions are located in the OTS Public Reading Room, Room 107, East Tower, Water-side Mall, 401 M St., S.W., Washington, DC.

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B. Supplemental Information

The following organizations responded to the Agency's request for information on nonylphenol for this Chemical Hazard Information Profile:

Submitter Name: Borg-Warner Chemicals, Inc.

EPA Document Control Number: FYI-OTS-0885-0438 INIT (Sequence A)

Information Types: Results of studies observing factors affecting the mortality of fish during acute static LC₁₀ and LC₅₀ testing.

Submitter Name: Occupational Physician

EPA Document Control Number: FYI-OTS-0585-0402 FLWP (Sequence B)

Information Types: Possible cause-effect relationship between product containing nonylphenol and multiple birth defects.

Submitter Name: National Institute for Occupational Safety and Health

EPA Document Control Number: FYI-OTS-0585-0402 FLWP (Sequence C)

Information Types: No information in the NIOSH Current Research File

Submitter Name: National Toxicology Program

EPA Document Control Number: FYI-OTS-0585-0402 FLWP (Sequence D)

Information Types: None of the nonylphenols tested or selected for testing by the NTP.

Submitter Name: Borg-Warner Chemicals, Inc.

EPA Document Control Number: FYI-OTS-0685-0402 FLWP (Sequence E)

Information Types: Uses of nonylphenol

Submitter Name: Schenectady Chemicals, Inc.

EPA Document Control Number: FYI-OTS-0685-0402 FLWP (Sequence F)

Information Types: Production volume, uses, manufacture, and exposure to nonylphenol

Submitter Name: Monsanto Industrial Chemicals Co.

EPA Document Control Number: FYI-OTS-0685-0402 FLWP (Sequence G)

Information Types: Product description, environmental effects, worker and environmental exposure, MSDS for nonylphenol

Submitter Name: Monsanto Industrial Chemicals Co.

EPA Document Control Number: FYI-OTS-0685-0402 FLWP (Sequence H)

Information Types: Production volume data claimed as confidential

Submitter Name: Texaco Chemical Co.

EPA Document Control Number: FYI-OTS-0685-0402 FLWP (Sequence I)

Information Types: Dermal toxicity data

Submitter Name: Occupational Physician

EPA Document Control Number: FYI-OTS-0885-0402 FLWP (Sequence J)

Information Types: Clinical report describing multiple birth defects

in child whose mother was exposed to a chemical
containing ethylene oxide; bibliography included

Submitter Name: Office of Pesticides Programs, U.S. Environmental
Protection Agency

Information Types: The OPP reports that polymeric materials containing
nonylphenol are used as inert ingredients in
pesticide formulations; no other information
available on nonylphenol

The following companies stated, in response to the USEPA request, that they
had no unpublished technical bulletins or reports on nonylphenol:

Celanese Corporation, New York, NY

E. I. Du Pont de Nemours & Co., Wilmington, DE

C. Secondary Sources Searched

1. Books

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2. Data Bases

<u>File</u>	<u>Number of References</u>	<u>Date of Search</u>
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Nonylphenol (mixed isomers);
4-Nonylphenol; 2-Nonylphenol

MEDLARS

TOXLINE 79-	83	April 1, 1985
TOX65	40	"
TOX76	64	"
MEDLINE	2	"
BACK80	3	"
BACK77	0	"
BACK75	1	"
BACK71	0	"
BACK66	0	"
CANCERLINE	0	"
CANCERPROJ	0	"
TDB	2	"
RIECS	1	"
CHEMLINE	3	"

LOCKHEED/DIALOG

BIOSIS PREVIEWS 69-76	6	"
BIOSIS PREVIEWS 77-80	14	"
BIOSIS PREVIEWS 81-	24	"
CHEM. EXP. 74-	0	"
CONG. REC. ABSTR. 76-	0	"
FED. REG. ABSTR. 77-	0	"
FED. RES. PROG. 82-	0	"
NTIS 64-	5	"

3. Search Strategy

The databases listed above were searched using CAS Registry Number, chemical name, and synonyms listed in the CHEMLINE printout. With the exception of the searches on the Chem Abstr files which were limited to non-patent references, all hits were "dumped" and computer printouts scanned for pertinent references.

D. Chemical Specific Sources Searched

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