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TOXIC SUBSTANCES CONTROL ACT

INTERAGENCY TESTING COMMITTEE

401 M Street, SW
Washington, DC 20460

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Consumer Product Safety Commission
Department of Agriculture
Department of Defense
Department of the Interior
Food and Drug Administration
National Toxicology Program

SEP 2 1981

Mr. James Hall
Conoco Chemicals
Box 2197
Houston, Texas 77001

Dear Mr. Hall:

Per our telephone conversation of September 1, 1981 I am pleased to enclose copies of the following Hazard Information Reviews prepared for the ITC by its technical support contractor:

IR-235: Mono(C_{10-16})Alkylbenzenes

IR-236: Mono($_{10-16}$)Alkylbenzenesulfonic Acids and their Sodium Salts

I wish to thank you for your cooperation in providing input of technical data to IR-235.

Sincerely yours,

Martin Greif

Martin Greif
Executive Secretary
ITC

Enclosures (2)

HAZARD INFORMATION REVIEW

Mono(C_{10-16})Alkylbenzenes

IR-235

July 15, 1981

Prepared under EPA Contract No. 68-01-5789 for:

TSCA Interagency Testing Committee

Prepared by:

Enviro Control
The Dynamac Building
11140 Rockville Pike
Rockville, MD 20852

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N O T I C E

THE INFORMATION CONTAINED IN THIS REVIEW WAS COMPILED FROM COMPUTERIZED DATA BASES, TECHNICAL LIBRARY RESOURCES, AND NON-CONFIDENTIAL INFORMATION IN GOVERNMENT FILES OR PROVIDED BY THE PRIVATE SECTOR.

THE PREPARATION OF THIS WORKING DRAFT IS JUST ONE STEP IN THE STUDY OF POSSIBLE HEALTH AND ENVIRONMENTAL HAZARDS OF THE CHEMICAL OR CATEGORY OF CHEMICALS DESCRIBED HEREIN.

THE EXISTENCE OF THIS REVIEW DOES NOT NECESSARILY IMPLY THAT THE ITC WILL RECOMMEND THE CHEMICAL TO THE EPA FOR TESTING RULES PROPOSAL.

Mono(C_{10-16})Alkylbenzenes

CONTENTS

PREFACE

This Information Review covers the commercial compounds known as "detergent alkylates." These compounds are produced and used as mixtures. The TSCA Inventory lists some of the components of the mixtures as well as the mixtures themselves.

Components of Detergent Alkalate Mixtures Listed in TSCA Inventory

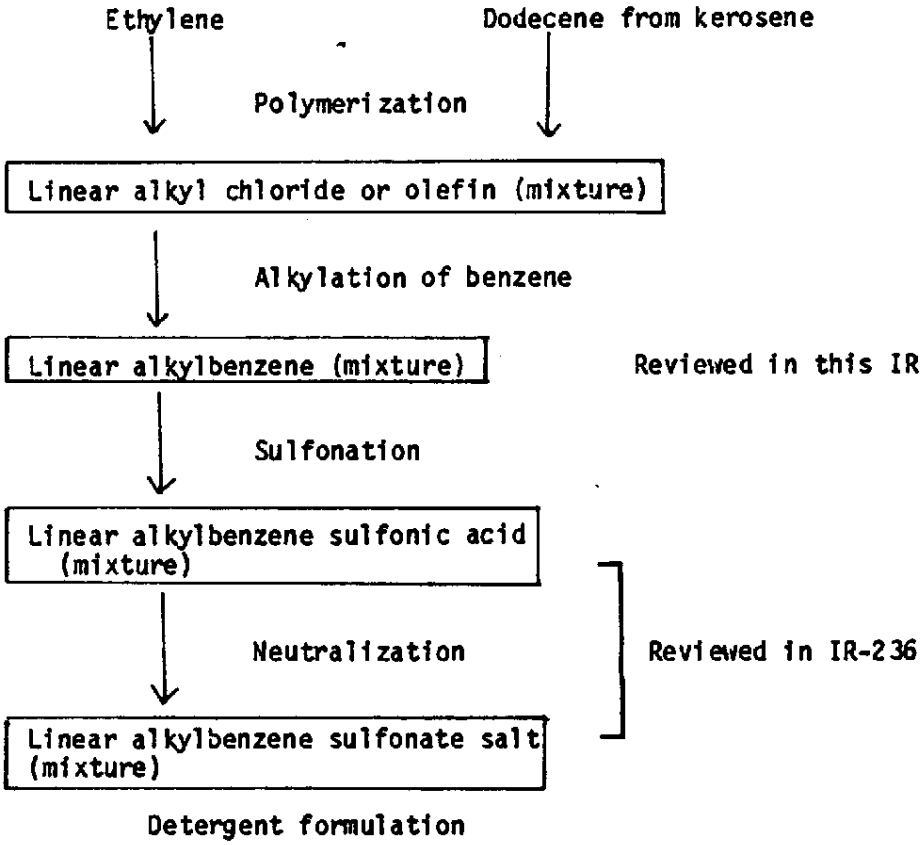
Empirical Formula	CAS No.	Name
$C_{16}H_{26}$ [a,b]	104-72-3	Decylbenzene
$C_{17}H_{28}$ [a,b]	6742-54-7	Undecylbenzene
$C_{18}H_{30}$ [a,b]	123-01-3	Dodecylbenzene
$C_{19}H_{32}$ [a,b]	123-02-4	Tridecylbenzene
$C_{20}H_{34}$ [a,b]	1459-10-5	Tetradecylbenzene
$C_{21}H_{36}$ [a]	2131-18-2	Pentadecylbenzene
$C_{22}H_{38}$ [a]	1459-09-2	Hexadecylbenzene
$C_{23}H_{40}$ [c]	14752-75-1	Heptadecylbenzene
$C_{24}H_{42}$ [c]	4445-07-2	Octadecylbenzene
$C_{25}H_{44}$ [c]	29136-19-4	Novadecylbenzene

[a]Normal "detergent alkylate" range.
[b]High-production chemicals selected for study by ITC in Third ITC Scoring Exercise.
[c]Related compounds.

Detergent Alkalate Mixtures Listed in TSCA Inventory

Empirical Formulas	CAS No.	Name
$C_{18}H_{30}$-$C_{24}H_{42}$	68890-99-3	Mono-C_{12}-C_{18}-alkyl-benzenes
$C_{16}H_{26}$-$C_{19}H_{32}$	67774-74-7	C_{10}-C_{13}-alkyl-benzenes
$C_{16}H_{26}$-C_{22}-H_{38}	68648-87-3	C_{10}-C_{15} alkyl-benzenes

The production of these compounds and their relationships to the linear alkylbenzenesulfonate detergents (LAS), which are the subject of IR-236, are summarized in the following scheme.



Before 1965, tetrapropylene (branched chain) was used to alkylate benzene. The detergents resulting from this process were not biodegradable and caused extensive foaming of wastewaters.

Mono(C_{10-16})Alkylbenzenes

I. CHEMICAL AND PHYSICAL PROPERTIES

A. IDENTIFICATION

Refer to Table 1.

B. FORMULAS AND MOLECULAR WEIGHTS

Refer to Table 1.

C. PHYSICAL PROPERTIES

Comment Physical properties for linear alkylbenzenes in this group are relatively scarce because the compounds are produced and used as mixtures. They are liquids or waxy solids with low solubility in water and boiling points above 255° C. The few data found appear to be for mixtures of isomers and compounds.

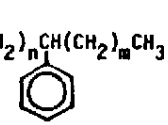
	Decylbenzene	Dodecylbenzene
Boiling Point:	255-280°C (TDB)	290-410°C (TDB)
Specific Gravity:	0.9 (TDB)	0.9 (TDB)
Log P octanol/water:	est. 7 (Leo et al., 1971)	est. 8 (Leo et al., 1971)
Impurities:	See Production Section I.E.1	

D. CHEMICAL PROPERTIES

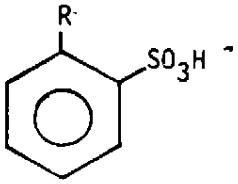
Comment: Linear (C_{10-16})alkylbenzene should exhibit most of the reactions of linear alkanes and alkyl-substituted aromatics (e.g., toluene).

Electrophilic substitution on the aromatic ring (e.g., nitration, sulfonation, and alkylation) is an important industrial reaction. The alkyl substituent on the benzene ring should activate the ring toward electrophylic substitution relative to benzene (Roberts and Caserio, 1964). However, the large alkyl group may tend to inhibit substitution due to steric effects.

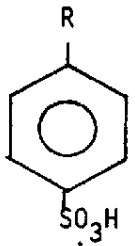
Table 1. Identification, formulas, and molecular weights of mono(C_{10-16})alkylbenzenes.

Name	Decylbenzene	Undecylbenzene	Dodecylbenzene	Tridecylbenzene	Tetradecylbenzene	Pentadecylbenzene	Hexadecylbenzene
CAS No.	104-72-3	6742-54-7	123-01-3	123-02-4	1459-10-5	2131-18-2	1459-09-2
NIOSH No.	None found						
Synonyms	Detergent alkylates, linear alkylbenzenes, LAB						
Structural formula	 where n + m = 7 to 11 (n = 0 to 11, m = 0 to 11) See Table 2 for isomer distribution.						
Empirical formula	$C_{16}H_{26}$	$C_{17}H_{28}$	$C_{18}H_{30}$	$C_{19}H_{32}$	$C_{20}H_{34}$	$C_{21}H_{36}$	$C_{22}H_{38}$
Molecular weight	218.39	232	246.48	260	274	288	302

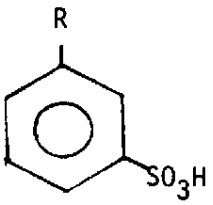
According to Papp et al. (1979), sulfonation of dodecylbenzene at 60°C yielded 5% para isomer, whereas sulfonation at 120°C yielded 15% para isomer. The remaining product in each case was the ortho isomer.



ortho isomer

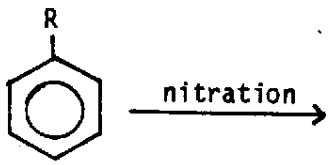


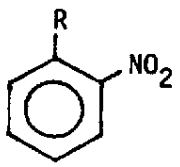
para isomer

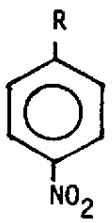


meta isomer

Comment: The source of these data is Chemical Abstracts; the ratio of ortho to para is different from the expected ratio as is shown below for nitration. According to Brandt and Verbesselt (1972), nitration of alkylbenzenes results in a predominance of para isomers even though there are two positions to be substituted.







	ortho isomer	para isomer
	Percent yield from nitrogen	
R= CH_3 (Toluene)	63%	37%
C_2H_5 (Ethylbenzene)	49%	51%
C_8H_{17} (Acetylbenzene)	46%	54%
$C_{10}H_{21}$ (Decylbenzene)	47%	53%
$C_{12}H_{25}$ (Dodecylbenzene)	46%	54%
$C_{16}H_{33}$ (Hexadodecylbenzene)	48%	52%

E. EXPOSURE ESTIMATES

The detergent alkylates are available commercially as complex mixtures of isomers and homologs in proportions dependent on starting materials and reaction conditions. The alkyl chains of commercially available alkylbenzene mixtures generally range from 10 to 14 carbons in length. The phenyl groups are attached at various internal carbon positions on the alkyl chain as indicated in Table 2 (A.D. Little, 1977). The commercial alkylbenzene product of most importance is referred to as "dodecylbenzene" (CPS, 1979), not to be confused with the compound dodecylbenzene (CAS No. 123-01-3).

1. Production

"Dodecylbenzene" is produced by alkylation of benzene with dodecene or dodecyl chloride in the presence of aluminum chloride, liquid hydrochloric acid, or sulfuric acid. Until 1965, dodecene was produced solely by polymerizing propylene with a phosphoric acid catalyst, which resulted in a branched chain dodecene. A branched chain dodecene is undesirable for environmental reasons, and since 1965 a linear dodecene has been used instead (Kirk-Othmer, 1978). The most important source of the linear compound is dodecane, which is removed from kerosene by molecular sieves. Linear dodecene may also be made by polymerization of ethylene or by the thermal cracking of paraffin wax to alpha-olefins (CPS, 1979).

The alkylation of benzene produces a number of side reactions resulting in products as shown in Figure 1. The linear monoalkylbenzene is purified by passing the reaction mixture through a series of three fractionating columns. The diphenylalkanes and dialkylbenzenes boil at temperatures sufficiently above those for the linear monoalkylbenzenes that they are readily removed. However, some of the other dialkylbenzene materials cannot be separated from the primary product with ease, and they remain in the commercial product. Dialkyltetralin, dialkylindane, and dialkylnaphthalene moieties may represent as much as 9-10% of the final product (A.D. Little, 1977).

Table 3 lists the 1977 production volumes of the alkylbenzenes as reported by the manufacturers to the TSCA Inventory (1981). Although the detergent alkylates are produced and sold as complex mixtures, several companies reported the production of the alkylates as individual compounds. Nonetheless, the aggregate production figures in the TSCA Inventory (1981) for the pure compound and the mixtures compares well with the production figures for the commercial product reported by CPS (1979) (Figure 2).

Table 2. Composition of representative commercial LAS products.[a]

	Percent of Total					
	Supplier A		Supplier B		Supplier C	
	Product 1	Product 2	Product 1	Product 2	Product 1	Product 2
Carbon chain length						
C_{10}	1	1	2[b]			
C_{10}	15	11	85	10[b]	15	1
C_{11}	43	31			43	2
C_{12}	35	32			35	12
C_{13}	7	23	15[b]	70-90	7	46
C_{14}	1	3	2[b]			38
C_{14}				5[b]		1
Phenyl position						
2-phenylalkane	32	30	25	25	33	29
3-phenylalkane	NA	NA	NA	NA	20	17
4-phenylalkane	NA	NA	NA	NA	18	16
5-phenylalkane	NA	NA	NA	NA	18	17
6-phenylalkane	NA	NA	NA	NA	11	15
7-phenylalkane	NA	NA	NA	NA		6
Tetralins and byproducts	6	7	NA	NA	6-10	6-10

[a]Manufacturers' specifications. Note that the data are for the finished linear alkylbenzenesulfonates (LAS), which reflect the composition of the starting materials (i.e., alkylbenzene).
[b]Maximum percentage.

Adapted from A.D. Little (1977).

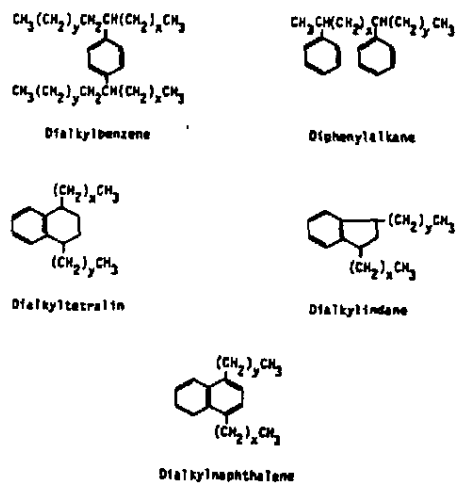


Figure 1. Products resulting from side reactions in the manufacture of linear alkylbenzenes.

From A.D. Little (1977).

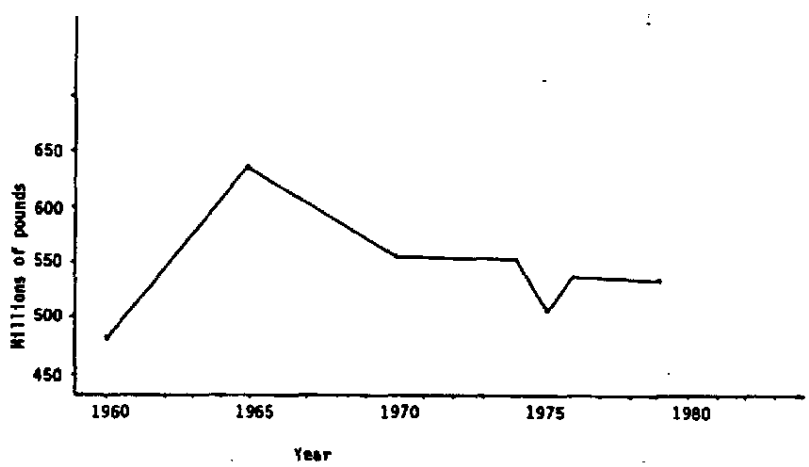


Figure 2. Production of commercial "dodecylbenzene" from 1960 to 1979 (CPS, 1979).

As is indicated in Figure 3, the production of "dodecylbenzene" has been static or slightly declining over the past 10 years. This trend is expected to continue (CPS, 1979).

Table 3. Production of the alkylbenzenes, 1977.

Compound	Production in millions of pounds
Decylbenzene	11 to 60
Undecylbenzene	61 to 160
Dodecylbenzene	61 to 160
Tridecylbenzene	12 to 70
Tetradecylbenzene	10 to 50
Pentadecylbenzene	1 to 10
Hexadecylbenzene	0 to 0.001
Heptadecylbenzene	0 to 0.001
Octadecylbenzene	0 to 0.001
Nonadecylbenzene	0 to 0.001
Mono-C_{12}-C_{18}-Alkylbenzenes	100 to 500
C_{10}-C_{13}-Alkylbenzenes	10 to 50
C_{10}-C_{16}-Alkylbenzenes	100 to 500

Adapted from TSCA Inventory (1981).

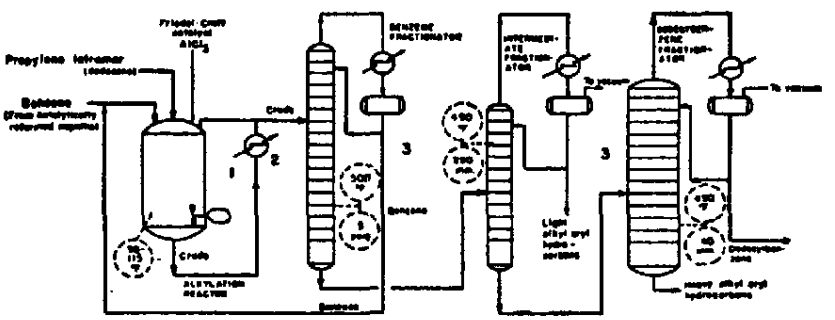


Figure 3. Flow diagram for "dodecylbenzene" manufacture using propylene tetramer. Substitution of dodecene for propylene tetramer should not alter the process (Riegel's, 1974).

2. Use (CPS, 1979)

"Dodecylbenzene" is used almost exclusively to produce dodecylbenzenesulfonic acid and sulfonate salts, which are widely used as anionic surfactants in heavy-duty home laundry detergents and industrial cleaners. The small amount of branched chain alkylbenzene produced is used in the manufacture of the sulfonate used in the United States as industrial detergents or in glass slurry processes, but not in household detergents or in any applications in which it could enter rivers or streams. Small amounts of "dodecylbenzene" are used in the manufacture of dodecylnitrobenzene, dodecyl aniline, and dodecyl benzyl chloride. The 1978 estimate of the end use pattern is as follows:

Derivative	Percent
Detergent alkylate	
Sodium salt	50
Acid	28
Other salts	15
Miscellaneous and Exports	7

3. Occupational Exposure

NOHS (1981) estimates that 13,961 workers are exposed to commercial "dodecylbenzene." Witco (1981) reported that "dodecylbenzene" is manufactured in a closed continuous system. In addition, the company reported that the personnel at Witco have not shown any adverse effects from "dodecylbenzene," and the company has been manufacturing the compound at an annual rate of 45 million pounds since 1966 (Witco, 1981).

Comment: The most likely route of exposure would be during the sulfonation process. Many manufacturers (greater than 25) purchase "dodecylbenzene" and sulfonate the compounds in preparation of the end product detergent.

4. Release Rate

Comment: Although Witco (1981) reports that alkylation hydrocarbons are manufactured in a closed continuous process, there may be pathways of release. The crude product of the reaction of benzene and dodecene is distilled three times: first through a benzene fractionator, then through an intermediate fractionator, and finally through a "dodecylbenzene" fractionator (see Figure 3). Two

byproducts of "dodecylbenzene" are collected during this process: a light alkyl aryl hydrocarbon cut and a heavy alkyl aryl hydrocarbon cut. These byproducts may be used in either fuel or asphalt or may be disposed of. One manufacturer reported to the TSCA Inventory (1981) that a C_{10-12} alkylbenzene distillation residue was manufactured in 1977 at levels between 1 million and 10 million pounds.

5. Manufacturers

CPS (1979) reports the following manufacturers of the commercial product "dodecylbenzene":

Conoco	Baltimore, Maryland
Monsanto	Alvin, Texas
Union Carbide	Institute, West Virginia
Witco	Carson, California

The manufacturers of the detergent alkalates reported in the TSCA Inventory are listed in Table 4.

F. SCORES FROM 1980 ITC SCORING EXERCISE

1. Occupational and Consumer Exposure

The exposure scores for the mono(C_{10-16})alkylbenzenes (normalized from 0.0 to 1.0) are as follows:

	Decyl	Undecyl	Dodecyl	Tridecyl	Tetradecyl
Occupational Exposure Index	--	--	0.63	--	--
Environmental/ Consumer Exposure Index	0.38	--	0.42	0.39	0.38

Table 4. The manufacturers of the alkylbenzenes, as reported in the TSCA Inventory (1981).

	Decyl	Undecyl	Dodecyl	Tridecyl	Tetradecyl	Pentadecyl	Hexadecyl	Heptadecyl	Octadecyl	Nonadecyl	C_{10}-C_{13}	C_{10}-C_{16}	Mono C_{10}-C_{14}	Mono C_{12}-C_{18}
Conoco, Baltimore, MD	*	*	*	*	*	*								
Chevron, Richmond, CA											*	*		
Witco, Carson, CA	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Union Carbide, Institute, WV	*	*	*	*									*	
Humphrey Chemical, North Haven, CT	*	*	*	*	*	*	*	*	*	*				
Monsanto, Alvin, TX														*
Gulf Oil, Houston, TX	*													
Stauffer, Akron, OH	*	*	*											
ICI America, Wilmington, DE			*											

*Manufacturer.

2. Health and Environmental Effects

Health and environmental effects were scored on a scale from 0 to 3 (minus assigned if score is based solely on judgment in the absence of experimental data).

Individual factor scores for the mono(C_{10-16})alkylbenzenes:

	Decyl	Undecyl	Dodecyl	Tridecyl	Tetradecyl
Mutagenicity	-1.0	-1.0	-0.8	-1.0	-1.0
Carcinogenicity	-1.1	-1.1	-1.3	-1.1	-1.1
Teratogenicity	-1.3	-1.3	-1.7	-1.3	-1.3
Reproductive effects	-1.3	-1.3	-1.3	-1.3	-1.3
Acute toxicity effects	-1.0	-1.0	0.3	-1.0	-1.0
Other toxic effects	-1.5	-1.5	-1.5	-1 5	-1.5
Bioaccumulation	2.0	2.0	2.0	2.0	2.0
Ecological	-2.0	-2.0	-2.0	-2.0	-2.0

II. BIOCHEMICAL INFORMATION

A. METABOLISM

"Dodecylbenzene" (of unspecified isomeric composition) administered to rats (5 ml/kg, subcutaneously) did not increase the urinary output of ethereal sulfate (Gerarde, 1960). This observation indicated to the author that the benzene ring is not hydroxylated in the metabolism of dodecylbenzene. However, increased output of ethereal sulfate has been observed by Gerarde and Ahlstrom (1966) in the metabolism of the lower molecular weight linear alkylbenzenes (C_1-C_6). This reaction occurs as an alternative pathway as the dose is increased. The main pathway is side chain oxidation.

Comment: By analogy with the lower alkyl benzenes, n-butylbenzene (El Masry et al., 1956), and n-pentyl- and n-hexylbenzene (Thierfelder and Klenk, 1924), some degree of oxidation of the alkyl side chain of the detergent alkylates may

be expected. The scheme proposed by El Masry et al. (1956) for the oxidation of n-butylbenzene in the rabbit is shown in Figure 4. Three possible pathways are shown in this figure. The first pathway (a) involves oxidation of the chain at the penultimate carbon, (ω-1)-oxidation, with production of an alcohol, which is excreted as a glucuronide conjugate. The second pathway (b) involves oxidation at the terminal carbon, ω-oxidation, to produce a carboxylic acid group. The third pathway (c) involves oxidation at the carbon adjacent to the benzene ring (α-oxidation). The corresponding alcohol may then undergo conjugation to form a glucuronide. Notice in Figure 4 that both (ω-1)-oxidation (pathway a) and ω-oxidation (pathway b) may result in eventual shortening of the carbon chain. In the case of n-butylbenzene, the degradation product shown in Figure 4 is phenaceturic acid, a conjugation product of phenyl acetic acid and glycine. Thierfelder and Klenk (1924) also observed phenaceturic acid in the urine of rabbits dosed with n-hexylbenzene.

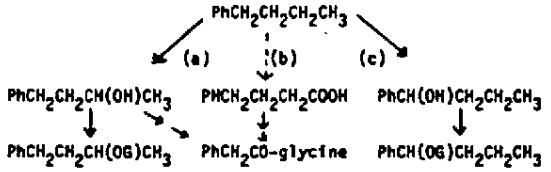


Figure 4. Oxidation of n-butylbenzene. The broken arrow indicates that there was no direct evidence for this pathway. (Ph = phenyl group, G = glucuronic acid residue).

Adapted from El Masry et al. (1956).

B. EFFECTS ON ENZYMES AND OTHER BIOCHEMICAL ASPECTS

No information available

III. TOXICOLOGICAL INFORMATION

A. CARCINOGENICITY

Dodecylbenzene (unspecified composition) is cocarcinogenic in nonhuman primates. No information is available on other monoalkylbenzenes.

Skin Carcinogenesis in Nonhuman Primates

Chemically induced cutaneous carcinogenesis in nonhuman primates was studied by Im (1968), Adachi et al. (1969), and Palotay et al. (1976). 7,12-Dimethylbenzanthracene (DMBA) combined with UV light and/or dodecylbenzene (DDB) was oncogenic when applied to the skin. Table 5 summarizes the results of cocarcinogenesis studies with dodecylbenzene in nonhuman primates and other mammals. No evidence was found to indicate that the compound itself is carcinogenic.

B. MUTAGENICITY

Dodecylbenzene is not mutagenic per se in cultured cells. However, it enhances the mutagenic effects of methylazoxymethanol. No information is available on other monoalkylbenzenes.

Mutagenic Effects on Cultured Cells

The potential of dodecylbenzene (unspecified composition) to enhance mutagenesis induced by the carcinogen methylazoxymethanol at the ouabain-resistance locus was examined by Lankas et al. (1978a*,b). Dodecylbenzene at a concentration of 0.7 mM enhanced the frequency of methylazoxymethanol-induced mutations in the cultured cells. The compound did not show mutagenic activity per se nor did it affect the cell survival rate.

C. TERATOGENICITY, EMBRYOTOXICITY, AND FETOTOXICITY

No information available

D. SPECIAL STUDIES

No information available

E. TOXICITY

The toxicity of a single dose of 2.5 ml of a mixture of "dodecylbenzene" in olive oil (1:1 v/v) to fasted rats weighing approximately 225 g was tested by Gerarde (1959). No deaths

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*An asterisk attached to a reference denotes that a Toxicological and Ecological Summary of the study is given in Section VII.

Table 5. Cocarcinogenesis by "dodecylbenzene" (unspecified) in nonhuman primates and other mammals.

Species	Route	No. of animals test group (control)	Dose	Effects	Reference
Mouse (C3H/He)	skn	10-15[a] (20)	0.05, 0.10, 0.20% benzo(a) pyrene in 0% to 100% DDB, 2 x wk.	Effects of 0.05 and 0.20% benzo(a)pyrene were indistinguishable when dodecylbenzene was used as a solvent (Enclosure 1).	Bingham and Falk (1969)
Mouse (Swiss)	"	10-60 (50 F)	Single application of a 1% sol. of 7,12-DMBA followed by repeated applications of pilot plant sample of alkylbenzene or commercial samples of alkylbenzenes.	No carcinogenic activity seen in commercial samples. However, promoting activity was shown by most of the samples (Enclosure 2).	Saffiotti et al. (1962)
Mouse (578L)	scu	30 MF (--)	Single injection of a 100% sol. of commercial sample of alkylbenzene.	No carcinogenic activity noted (Enclosure 3).	"
Rabbit (New Zealand albino)	skn	3-5[a] (--)	Twice weekly application of a 100% sol. of two commercial samples of alkylbenzene.	"	"
Rhesus monkey (Macaca mulatta)	"	3 M, 3 F (--)	1.0% 7,12-DMBA (total dose 20.28 g) + 100% DDB 3 x wk for 6.5 yr + UV light for 5 min, 3 x wk for 6.5 mo.	Ten years after the treatment, dermal melanosis (1), papillomas (6), basal cell epithelioma (3), and mesodermal sarcomas (2) developed. However, use of control animals was not stated.	Palotay et al. (1976)
"	"	6 MF (6 MF)	Two parts of the experimental area were painted with 0.8 ml of 1% solution of 7, 12-DMBA in acetone + 1 ml of of 100% DDB. Prior to the treatment one of the two experimental areas was exposed to UV light (2 x 10^4 ergs/cm^2). One of the two control areas was treated with 0.5 ml of DDB and acetone after UV irradiation. Other control area was treated only with acetone after exposure to UV light. Animals were painted 3 x 3k for 5 mo and 2 x wk for the next 7 mo.	Small papillomas on the skin at 2.5 mo and keratoacanthomas at 8 mo. Marked quantitative changes in G6PDH[b] and 6PGDH[c] activities were found between treated (tumor and hyperplastic) and normal tissues.	Im (1968)

(continued)

[a]Sex not stated.

[b]Glucose-6-phosphate dehydrogenase.

[c]6-Phosphogluconate dehydrogenase.

Table 5. Cocarcinogenesis by "dodecylbenzene" (unspecified) in nonhuman primates and other mammals (continued).

Species	Route	No. of animals test group (control)	Dose	Effects	Reference
Galagos (Galago crassicaudatus)	skn	4 M, 4 F (4 M, 4 F)	2.5% 7,12-DMBA (total dose 2.22 g) + 100% DDB 3 x wk for 9 wk, then 100% DDB 2 x wk for 4 yr. Control site (lower third) was treated with acetone + DDB.	3 papillomas, 2 basal cell epitheliomas, and 4 cases of basosquamous cell epidermal tumors were found in 7 of 8 animals 8 yr after treatment.	Palotay et al. (1976)
"	"	4 M, 4 F (4 M, 4 F)	0.2 ml of 2.5% 7,12-DMBA in acetone + 0.5 ml of DDB 3 x wk. Control area was treated with acetone and DDB 3 x wk.	After 4-5 wk, animals developed pseudoepitheliomatous hyperplasia. G6PDH and 6PGDH activity was higher in hyperplastic than in normal epidermis.	Adachi et al. (1969)
Pottos (Perodicticus potto)	"	3 M, 4 F	"	"	"
"	"	"	2.5% 7,12-DMBA (total dose 0.135 G) + 100% DDB 3 x wk for 9 wk. Control site (lower third) was treated with acetone + DDB.	6 of the 7 animals died by 9 wk. Survivor showed no cutaneous lesions.	Palotay et al. (1976)

[a]Sex not stated.
[b]Glucose-6-phosphate dehydrogenase.
[c]6-Phosphogluconate dehydrogenase.

occurred in the 10 rats dosed. Gerarde (1960), citing his 1959 study, indicated that the acute oral toxicity of "dodecylbenzene" (unspecified composition) is greater than 5 ml/kg for the male rat.

The direct aspiration of "dodecylbenzene" into the lungs of tracheoctomized rats caused chemical pneumonitis, pulmonary hemorrhage, and death (Gerarde, 1960). Based on analogy with similar hydrocarbons, Gerarde (1960) suggests that prolonged exposure to "dodecylbenzene" vapor or mist at relatively high atmospheric concentrations would cause local irritation of the mucous membranes of the nose, throat, and eyes. Similarly, prolonged or repeated contact of a detergent alkylate (i.e., "dodecylbenzene") with the skin may cause dermatitis due to drying and removal of the natural fats from the cutaneous tissues (Gerarde, 1960).

IV. OBSERVATIONS IN HUMANS

Witco (1981), indicated that Dodane-S (composed of alkylbenzenes, C_{10-14}) has been handled and produced since 1966 at an annual rate of 45 million pounds in a closed system without adverse effects on the personnel involved. Witco indicated that some people may have an allergic response to Dodane-S and Tridane-S (alkylbenzenes, C_{11-15}).

V. ENVIRONMENTAL INFORMATION

A. ENVIRONMENTAL RELEASE AND CONCENTRATIONS

1. Environmental Entry

C_{10-16} linear alkylbenzenes are prepared in continuous closed processes (Witco, 1981). The compounds are used as intermediates in the formation of linear alkylbenzenesulfonates. The alkylbenzenes are not used in any consumer products (Conoco, 1981) and potential exposure is limited to the plants where they are manufactured and processed.

2. Environmental Concentrations

Somain et al. (1980) reported results of monitoring industrial discharges along the Illinois River. C_{10}-C_{16} alkylbenzenes were observed at one source only, which was described as a manufacturing site for surfactants, detergents, plastic moldings." In this sample, they found traces of "dodecylbenzene" and pentadecylbenzene. It is noteworthy that these compounds were not observed in effluents from petrochemical plants and refineries.

B. ENVIRONMENTAL FATE

The following comments give our projection of the environmental fate of linear alkylbenzenes based on certain experimental results and our judgment of how these results relate to environmental processes.

1. Partitioning Among Environmental Compartments

The methods of production and use of linear alkylbenzenes suggest that they are mainly released into water effluents or "solid" waste. Their low volatility limits vaporization into the air. Their octanol/water partition coefficients are estimated to be very high (e.g., log P = 7-10, Leo et al., 1971), which implies low solubility in water and a strong tendency to sorb to humic materials in soil and sediments.

2. Aquatic Chemistry

Because of the strong tendency of these substances to sorb to sediments, photolysis and related reactions, which often destroy organic compounds in water, may be inhibited (Oliver et al., 1979).

3. Atmospheric Chemistry

Because of their low volatility, C_{10}-C_{16} alkylbenzenes are most likely to enter the atmosphere in the form of aerosols. Photolysis or hydroxyl radical oxidation of these materials as aerosols is expected to be rather slow. However, the alkylbenzenes as a class are regarded as readily degradable by hydroxyl radical oxidation (Darnell et al., 1976).

4. Biodegradation

Two types of compounds must be considered for biodegradation: compounds with the phenyl ring attached to the end of the linear alkyl chain, and compounds with the phenyl ring attached to a secondary carbon in the linear alkyl chain (e.g., usually adjacent to the end carbon).

a. Linear alkylbenzenes with the phenyl group attached to an end carbon

Sariaslani et al. (1974) described results of the degradation of linear 1-alkylbenzenes. When Nocardia salmonicolor was grown on (linear) 1-dodecylbenzene as the sole carbon source, there were two periods of growth. Each period was preceded by a lag phase during which enzyme induction occurred.

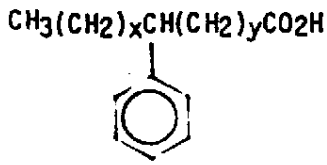
The initial metabolism of "dodecylbenzene" involved oxidation of both the aromatic ring and the side chain. The metabolites that accumulated in the growth medium during this phase included 4-phenylbutyrate, 4-phenylbut-3-enoate, 4-phenylbut-2-enoate, 3-phenylpropionate, cinnamate, and phenylacetate. These compounds were consumed as the first growth phase came to an end and ring-hydroxylated compounds were produced. Ring-hydroxylated metabolites included 4-(2-hydroxyphenyl) but-3-enoate and 4-(2-hydroxyphenyl) butyrate.

The second growth phase is accomplished by cleavage of the aromatic ring and oxidation to acetoacetic acid and fumaric acid.

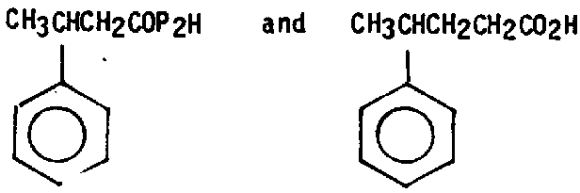
The most important features of the scheme observed by Sariaslani et al. (1974) are shown in Figure 5.

b. Linear alkylbenzenes with the phenyl group attached to a secondary carbon

Detergent alkylates are mixtures of isomers in which the phenyl group is almost always substituted on a secondary carbon of the alkyl chain (i.e., almost never on the terminal carbons). Degradation of these structures by the ω-oxidation pathway shown in Figure 5 would yield structures of the type:



Leidner et al. (1980) reported on the biodegradation of some phenylalkylcarboxylic acids. Some structures seem to be more resistant to degradation than others. For example, within 16 days in mixed culture induced with readily degradable phenylalkylcarboxylic acids, the two compounds



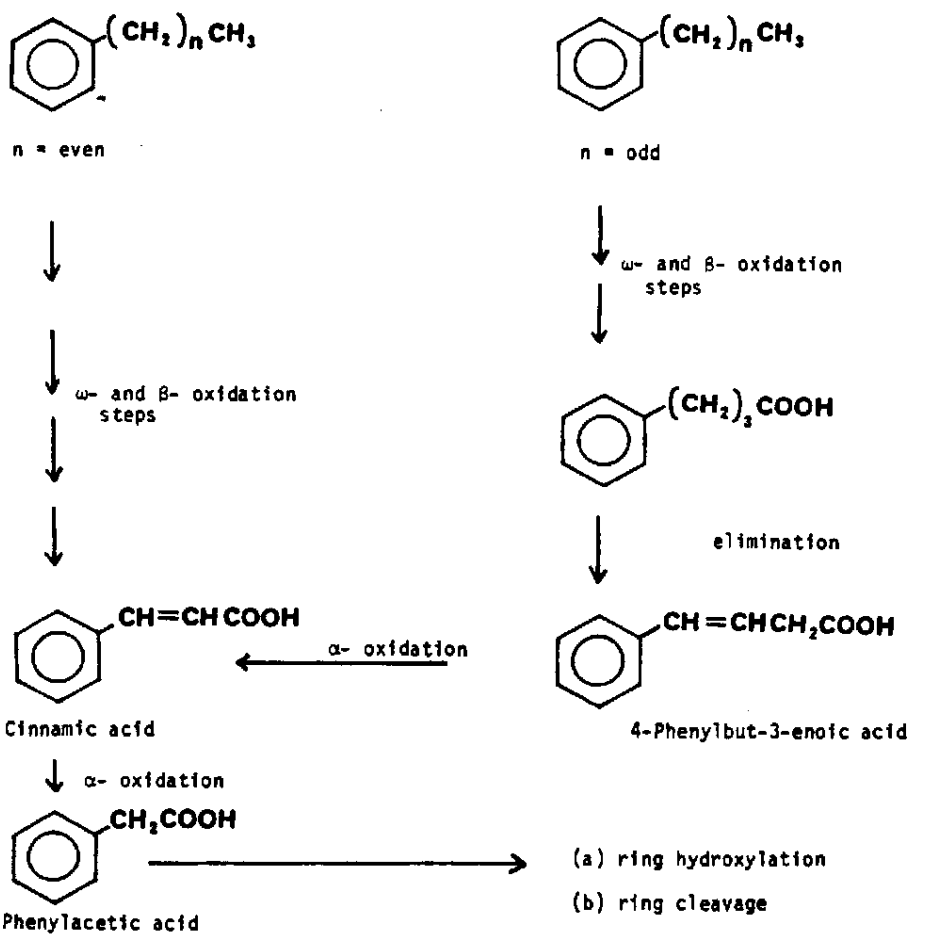


Figure 5. Microbial degradation of alkylbenzenes with benzene attached to terminal carbon.

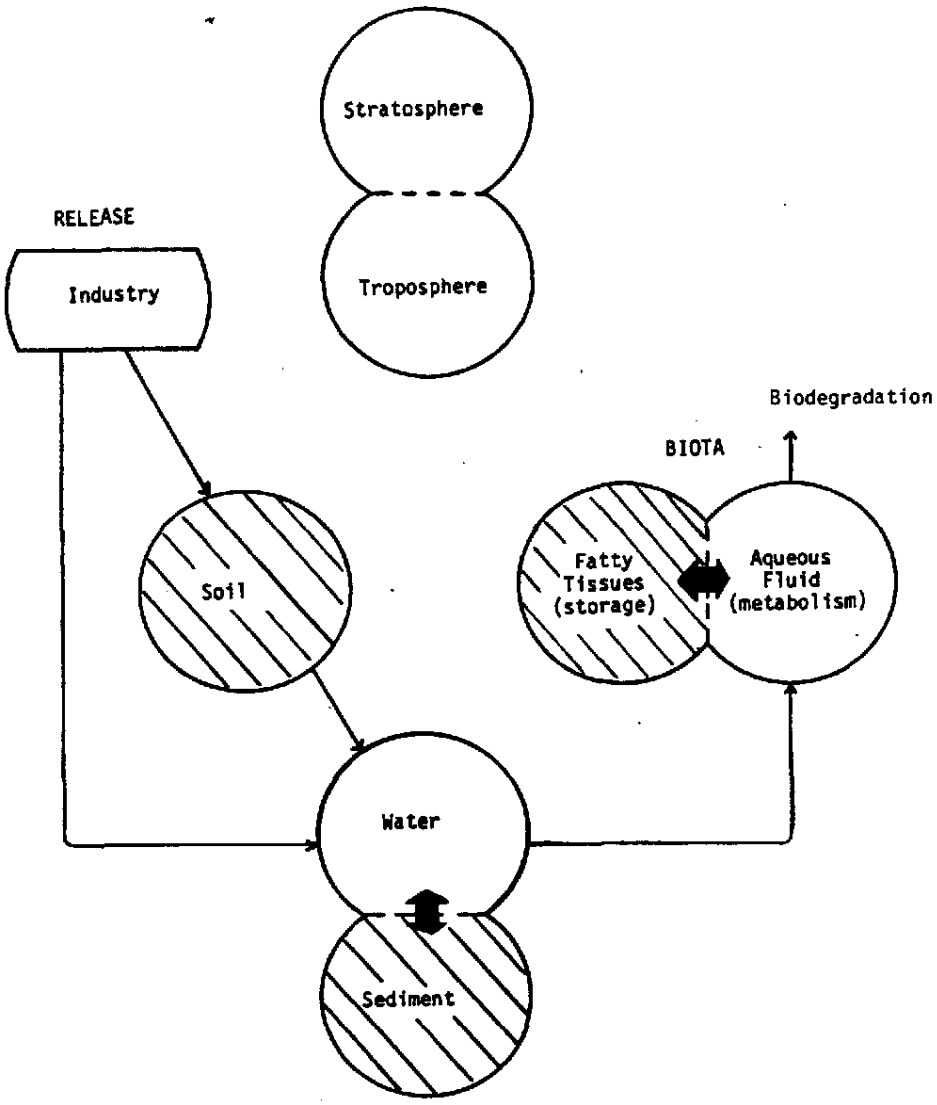


Figure 6. Projected environmental fate of (C_{10-16})alkylbenzenes. These compounds are expected to partition into soil, sediment, and fatty tissue. The rate of biodegradation does not appear to be great enough to prevent accumulation in the compartments as indicated by the hatching.

VI. DATA BASES SEARCHED AND AUTHORS

A. DATA BASES SEARCHED

MEDLARS

MEDLINE	1966-present
CHEMLINE	1968-present
RTECS	1977-present
TDB (Toxicology Data Bank)	1977-present
TOXLINE	1977-present
TOX 65	1965-1973
TOX 74	1974-1976
CANCERLINE	1967-present
CANCERPROJ	1967-present

ORBIT

APILIT	1964-present
APIPAT	1964-present
BIOSIS	1979-present
BIOSIS 7479	1974-1979
CAS67	1967-1971
CAS72	1972-1976
CAS77	1977-present
CIN (Chem. Indust. Notes)	1974-present
COMPENDEX	1970-present
CDI (Comprehensive Dissert. Index)	1861-present
CONFERENCE PAPERS INDEX	1973-present
ENVIROLINE	1971-present
FSTA (Food Sci. Technology Abs.)	1969-present
NTIS	1970-present
OCEANIC	1964-present
PAPERCHEM	1969-present
P/E NEWS	1975-present
POLLUTION ABSTRACTS	1972-present
SAFETY	1975-present
SSIE (Social Science Citation Ind.)	1979-present
TITUS	1967-present

DIALOG

AGRICOLA	1970-present
APTIC	1966-1978
AQUACULTURE	1970-present
AQUALINE	1974-present
AQUATIC SCIENCE FISHERIES ABSTRACTS	1978-present
CAB ABSTRACTS	1973-present
CLAIMS/US PATENT ABSTRACTS	1971-present
CRIS/USDA	1974-present
ENERGYLINE	1971-present
ENVIRONMENTAL BIBLIOGRAPHY	1974-present
EXCERPTA MEDICA	1974-present
FOODS ADLIBRA	1974-present
INSPEC	1969-present
INTERNATIONAL PHARM. ABS	1970-present
ISMEC	1973-present
IRL LIFE SCIENCES COLLECTION	1978-present
MANAGEMENT CONTENTS	1974-present
PHARM. NEWS INDEX	1975-present
PTS PROMT	1972-present
RAPRA ABSTRACTS	1972-present
SCI SEARCH	1974-present
SURFACE COATING ABSTRACTS	1976-present
WELDA SEARCH	1967-present
WORLD TEXTILES	1970-present

B. AUTHORS

This Information Review was prepared by a multidisciplinary team of scientists and technicians. Dr. Satish Bhalla was the principal author and compiler.

VII. TOXICOLOGICAL AND ECOLOGICAL SUMMARY

From Lankas et al. (1978).

TOXICOLOGICAL AND ECOLOGICAL SUMMARY

Authors: Lankas GR, Baxter CS, Christian RT
Date: 1978
Title: Effect of alkane tumor-promoting agents on chemically induced mutagenesis in cultured V79 Chinese hamster cells
Journal: J. Toxicol. Environ. Health 4:37-41

Chemical: Dodecylbenzene (unspecified composition)

Biological Parameter Examined: Mutagenicity

Species/Tissue: Chinese hamster cells V79

Technique:

V79 Chinese hamster cells were grown in Eagle's minimum essential medium supplemented with 1.5 X vitamins and amino acids and 10% fetal calf serum. For routine culture the cells were grown in 75 cm^2 plastic tissue culture bottles without antibiotics in an atmosphere of 95% air and 5% CO_2. For the mutagenesis assay 2 x 10^5 cells were seeded in 100-mm plastic petri dishes in 10 ml growth medium supplemented with 100 units penicillin and streptomycin at 100 µg/mL. After 2-4 hours, to allow for cell attachment, methylazoxymethanol acetate (MAM) dissolved in medium without serum was added to the plates to a final concentration of 24 µg/mL. After 24 hours of exposure, the medium in the plates was removed and replaced by fresh medium plus the chemical being tested for promoting activity.

Dodecylbenzene was mixed with acetone (20 µL/mL) to give a 0.2% v/v solution. Tetradecanoyl acetate diester (TPA) was dissolved in acetone to a concentration of 1 mg/mL. Aliquots of these solutions were added to the cultures after removal of the mutagen. The plates were gently swirled to ensure an even distribution of the chemical. Ouabain-resistant mutants were selected by adding growth medium containing 1mM ouabain 48-72 hours after dosing with MAM. The alkanes were again added so that exposure to the promoter continued throughout ouabain selection. After 2 weeks, the plates were washed, fixed with ethanol, and stained with Giemsa, and the number of mutant colonies was determined. Replicates of 10 plates per point were made.

Objective

To test linear alkanes, an aryl derivative of dodecane and a phorbol ester, for their ability to enhance mutagenesis induced by the chemical carcinogen MAM.

TOXICOLOGICAL AND ECOLOGICAL SUMMARY (continued)

Effects Observed

At a concentration of 0.7 mM, dodecylbenzene enhanced the frequency of MAM-induced mutations in the cultured cells (Table 1). Dodecylbenzene neither showed mutagenic activity per se nor had an effect on the cell survival rate.

Table 1. Comparison of effects of the tetradecanoyl acetate diester (TPA) of phorbol and 1-phenyldodecane on mutation frequency in V79 cells.

Treatment	Survival (%)	Avg. no. mutants per plate	Mutants per 10^6 survivors
Control	90	1.0 ± 0.5	5.6
TPA (1.6 μM)	88	0.5 ± 0.6	2.8
1-Phenyldodecane(0.7 mM)	41	0.4 ± 0.6	2.2
MAM[b] (24 μg/mL)	29	20.9 + 2.5	360
MAM + TPA[c]	27	26.9 ± 2.3	498[d]
MAM + 1-Phenyldodecane	29	27.7 ± 3.5	479[d]

[a]Average ± 95% confidence interval (t-test).
[b]MAM - Methylazoxymethanol acetate.
[c]TPA - Tetradecanoyl acetate diester.
[d]$p < 0.05$

ENCLOSURES

Enclosure 1: From Bingham and Falk (1969).

Enclosure 2: From Bingham and Falk (1969).

Enclosure 3: From Saffiotti et al. (1962).

Table 4.—*The Cocarcinogenic Activity of Various Concentrations of 1-phenyldodecane With Three Concentrations of Benzo[a]pyrene*

Concentration of Carcinogen and Cocarcinogen	Original No. of Mice	Final Effective No. of Mice	No. of Mice Developing Tumors		Av Interval Until Appearance of Tumors (weeks)
			Malignant	Benign	
0.05% Benzo[a]pyrene					
1-phenyldodecane					
0	20	15	12	3	60
10	15	15	15	0	29
20	15	15	14	1	23
30	15	14	12	1	22
40	15	15	15	0	18
50	10	10	9	1	16
70	10	8	8	0	13
100	10	10	9	1	11
0.10% Benzo[a]pyrene					
1-phenyldodecane					
0	20	18	15	3	47
10	15	14	11	0	25
20	15	15	12	3	23
30	15	14	14	0	20
40	15	15	15	0	18
50	10	9	8	1	18
70	10	8	6	2	13
100	10	10	10	0	12
0.20% Benzo[a]pyrene					
1-phenyldodecane					
0	20	20	20	0	40
10	10	10	10	0	21
20	10	8	8	0	21
30	10	8	8	0	19
40	10	10	10	0	16
50	10	9	9	0	17
100	10	10	10	0	10

Enclosure 2
From Bingham and Falk (1969)

TABLE 1

SKIN TESTS IN SWISS FEMALE MICE, USING TWICE WEEKLY TOPICAL APPLICATIONS OF ALKYLBENZENES

Initiator	Alkylbenzene sample	Initial number of animals	Duration of the experiments (weeks)	Number of tumor-bearing animals	Total number of tumors	
					Benign	Malignant
None	O (pilot plant)	10	50	4	8	2
	O[b]	20	76	1	0	1
	O[b,c]	20	85	0	0	0
	A	60	69–76	0	0	0
	B	40	74–83	1	2	0
	C	40	74–80	0	0	0
	D	40	61–83	2	2	0
	E	40	80–86	1	1	0
	F	20	81	0	0	0
	G	20	72	1	2	0
DMBA[a]	O (pilot plant)	10	50	6	29	3
	O[b]	20	76	11	24	4
	O[b,c]	20	71	3	3	0
	A	20	78	2	1	1
	B	20	78	5	6	1
	C	20	78	1	1	1
	D	20	85	5	6	2
	E	20	70	3	5	2
	—[d]	50	62	0	0	0

[a] One application of a 1% solution in mineral oil of 7,12-dimethylbenz[a]anthracene.

[b] Retested after storage for one year in presence of air.

[c] Fluorescent-free.

[d] Received only the single application of DMBA.

Enclosure 3
From Saffiotti et al. (1962)

TABLE 2

SKIN TESTS IN RABBITS, USING TWICE WEEKLY TOPICAL APPLICATIONS OF ALKYLBENZENES AND ABS

Sample	Concentration (%)	Initial number of animals	Duration of the experiment (weeks)	Number of tumor-bearing animals	Total number of tumors	
					Benign	Malignant
→ Alkylbenzene sample B	100	5	110	1	1	0
→ Alkylbenzene sample D	100	5	110	0	0	0
ABS made from sample D	10 (aq.)	5	115	0	0	0

TABLE 3

SUBCUTANEOUS TESTS IN C_{3H} BLACK MICE FOLLOWING A SINGLE SUBCUTANEOUS INJECTION OF A 1% SOLUTION IN TRICAPRYLIN OF ALKYLBENZENE AND ABS

Sample	Initial number of animals	Duration of the experiment (weeks)	Number of tumor-bearing animals	Total number of tumors	
				Benign	Malignant
→ Alkylbenzene sample D	30	95	0	0	0
ABS made from sample D	30	95	0	0	0

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