CONTACT AND FUMIGANT TOXICITY OF OILS, SURFACTANTS, AND INSECTICIDES TO TWO APHID AND THREE BEETLE SPECIES [1]

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Surfactants and oils are organic compounds possessing manifold properties and are added to insecticides to aid emulsification, dispersion, or solubility. The surfactants and oils include those compounds often designated as emulsifiers, solvents, co-solvents, carriers, stickers, spreaders, and other terms. Although surfactants and oils possess 1 or more of these properties, additional information is needed on their insecticidal properties. A comparative investigation of various surfactants, oils, and insecticides was initiated to (1) determine the insecticidal properties of various surfactants and oils against cabbage aphid, *Brevicoryne brassicae* (L.), green peach aphid, *Myzus persicae* (Sulzer), a weevil, *Sitophilus zea-mais* (Motschulsky), red flour beetle, *Tribolium castaeum* (Herbst), and cowpea curculio, *Chalcodermus aeneus* Boheman under laboratory conditions; (2) show the effect of the volatile phase of petroleum oils on green peach aphid mortality; and (3) show the effect of various insecticides against cowpea curculio and cabbage aphids under laboratory conditions.

Corey and Langford (1935), Dills and Menusan (1935), Dozier (1937), and Turner et al. (1951) evaluated various surfactants for insect mortality under laboratory conditions. Reihl et al. (1965) indicated significant kill of citrus red mite eggs from surfactants in various citrus spray oils.

METHODS AND MATERIALS

All experiments were conducted in the laboratory. The aphid adults and cowpea curculio larvae were field collected from cabbage leaves and Southernpea peas. The weevil and beetle adults were reared in the laboratory in gallon cylindrical cardboard containers containing untreated grain sorghum seed.

The experiments were conducted in a laboratory maintained at 27 ± 4° C. The insecticides were prepared in parts per million concentrations in acetone. The surfactants and oils were prepared in solutions of 10 different percentages at 10% intervals beginning at 100%. Whatman No. 1 filter paper (9 cm) was dipped into the various oils (emulsified by a 1% concentration of Triton B-1956), surfactants, and insecticide concentrations, removed and blotted. After blotting, the saturated papers were

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TABLE 1.—LABORATORY EVALUATIONS OF OILS AND SURFACANTS FOR CABBAGE APHID AND COWPEA CURCULIO MORTALITY, 1963-1964.

Oil or surfactant			Percent oil or surfactant for mortality of—			
			Cabbage aphid		Cowpea curculio	
Type	Name	Chemical name	LC_{50}	LC_{90}	LC_{50}	LC_{90}
	IP 1		5	12	—	—
	IP 2		9	40	*	**
	SP 2		25	73	31	**
	SP 3		12	95	*	**
	SP 4		33	77	*	**
	N 3		13	100	75	**
	N 4		7	100	72	**
	N 5		41	100	85	**
	P 4		15	30	*	**
	P 5		23	64	*	**
	P 6		27	100	*	**
Nonionic	Retzanol M-139	Polyoxyethylene thioether	—	—	1	54
Nonionic	Retzloff L775	Mixed fatty acids and oxyalkylated dinonyl phenols	—	—	1	54
Nonionic	Retzloff 50	Mixed fatty acids and oxyalkylated dinonyl phenols	—	—	2	60
Nonionic	Triton X-100	Ethoxylated isooctyl phenyl polyethoxyethanol (9-10 moles)	1	76	—	—
Nonionic	AF-100	Polyethylene glycol ether of nonylphenol	2	6	—	—
Nonionic	B1956	Modified phthalic glycerol alkyd resin	4	28	—	—

* Less than 50% mortality at 100% concentration.
** Less than 90% mortality at 100% concentration.

placed in petri dishes (1 paper in each of 4 dishes), and 100 to 400 of the insects (10/dish with 4 replicates/dose) were added. Except as indicated for the green peach aphid experiment presented in Table 4, the petri dish cover was placed over the petri dish bottom. In that experiment the aphids were placed in both enclosed and open petri dishes. The enclosure of the petri dishes was assumed to prevent vapors from escaping. The open dishes had fine mesh plastic screen placed over the lower dish to prevent the aphids from escaping. Percentage mortality was corrected by Abbott's formula. The checks consisted of 4 replications of water-treated filter paper and were employed for each material evaluated.

The data are presented as percent surfactant or ppm of insecticide required to kill 50% or 50 and 90% of the test insects (LC_{50} or LC_{50} and LC_{90}) from eye fitted lines. Some chemical and physical properties and naming system of the oils used in these evaluations are summarized by Wolfenbarger (1964a, 1964b). The surfactants are identified by type, name, and chemical name by McCrutecheon (1965).

Results and Discussion

Isoparaffinic (IP) oils gave the greatest, and the special paraffinic (SP) oils the lowest cabbage aphid mortality (Table 1). The lower molecular

TABLE 2.—Insecticides for Cabbage Aphid and Cowpea Curculio Mortality.

Insecticide	LC_{50} (ppm)
Cowpea curculio	
Toxaphene	0.02
Dieldrin	36
Parathion	>100
DDT	>100
Cabbage aphid	
TDE	< 0.001
Methyl parathion	1.5
Parathion	1.6
Perthane®*	1.6
Dieldrin	8
Zectran®*	10
Endrin	20
Malathion	50
Mevinphos	59
Telodrin®*	66
Bidrin®*	>100

* Trademarked and carrying chemical definition:
Perthane (a mixture of 1,1-dichloro-2,2-bis(*p*-ethylphenyl)ethane (95%) and related products (5%).
Zectran (4-dimethylamino-3,5-xylyl methylcarbamate).
Telodrin (1,3,4,5,6,7,8,8 octachloro 3a,4,7a-tetrahydro-4,7-methanoisobenzofuran).
Bidrin (3-hydroxy-N,N-dimethyl *cis*-Croton-amide dimethyl phosphate).

TABLE 3.—SURFACTANTS FOR GREEN PEACH APHID MORTALITY.

Type	Name	Chemical name	Percent for LC_{50}
Anionic	Triton GR-7	Sulfonated alkyl esters	5
Nonionic	Pronon 505	Ethoxylated alkyl polyoxyethylene ethanol (5 moles)	8
Nonionic	Retzanol M-139	Polyoxyethylene thioether	14
Cationic	Catanac SN	Stearamido propyldi-methyl-B-hydroxyethyl ammonium nitrate	14
Nonionic	Ahco Base Oil 90	Oleic acid-ethylene oxide condensate	16
Nonionic	Pronon 504	Ethoxylated alkyl polyoxyethylene ethanol (4 moles)	16
Nonionic	Sterox AJ	Polyoxyethylene ether	18
Nonionic	Tergitol TMN	Ethoxylated trimethyl nonyl ether of polyethylene glycol (6 moles)	19
Nonionic	Pronon 506	Ethoxylated alkyl polyoxyethylene ethanol (6 moles)	20
Cationic	Aerosol C-61	An ethanolated alkylguanidine amine complex	21
Nonionic	Protox 7704A	Mixed alkyl and alkyl aryl polyalkyloxylates	23
Nonionic	AF100	Polyethylene glycol ether of nonylphenol	26
Nonionic	Retzloff NS-29	Oxyalkylated tridecyl alcohol	28
Nonionic	Propylene glycol monococate C	Fatty acid ester	29

(continued)

TABLE 3.—(continued)

Type	Name	Chemical name	Percent for LC_{50}
Anionic	Protox 7712	Normal C-10 alkylethoxyethanol	29
Anionic	Agrimul N4R	Aromatic sulfonate-oxide condensate blend	34
Nonionic	Protox 7700	Blend of sorbitan oleate ester with a dialkyl aryl ethoxylate	34
Cationic	Arquad C-50	N-alkyl trimethyl ammonium chlorides	38
Nonionic	Retzanol M-139	Polyoxyethylene thioether	40
Cationic	Catanac SP	Stearamido propyldi-methyl-B-hydroxyethyl ammonium phosphate	41
Nonionic	Tween 20	Polyoxyethylene sorbitan monolaurate	49
Nonionic	Carbowax 600	A polyethylene glycol	52
Nonionic	B1956	Modified phthalic glycerol alkyd resin	56
Nonionic	Colloidal X-77	Alkyl arylpolyoxyethylene glycols, free fatty acids, isopropanol	*
Nonionic	Plyac	Emulsifiable A-C polyethylene 629; fatty acid-amine concentrate; alkyl aryl sulfonate	*

* Less than 50% mortality at 100% concentration.

weight SP oil gave the greatest cowpea curculio larval mortality. AF 100 gave the greatest cabbage aphid mortality. In general, the surfactants gave greater mortality than oils against cabbage aphid adults and cowpea curculio larvae.

Toxaphene was the most effective insecticide against the cowpea curculio (Table 2). More than 100 ppm were required to give 50% larval mortality with DDT and parathion. TDE, parathion, Perthane®, and methyl parathion gave the greatest cabbage aphid mortality.

Triton GR-7, Pronon 505, Catanac SN, and Retzanol M-139 gave the greatest green peach aphid mortality (Table 3).

The data (Table 3) indicate that nonionic surfactants gave from 100 to 15% mortality to aphids at concentrations of 50 to 100% showing extremes in toxicity that may occur within the nonionic surfactants. A comparison of AF 100 and B 1956 for cabbage aphid (Table 1) and green peach aphid (Table 3) mortality showed that greater mortality of cabbage aphid occurred than with green peach aphid suggesting selective toxicity between these surfactants.

At 21% concentration the paraffinic (P) and naphthenic (N) oils in the enclosed petri dish gave 50% mortality of green peach aphids while 50% mortality was not obtained for aphids in open dishes at concentrations of 100% oil (Table 4), indicating that the oil fractions evaluated cause most of their mortality by fumigant action and not by contact with the oils.

TABLE 4.—THREE OIL FRACTIONS IN ENCLOSED AND OPEN PETRI DISHES FOR GREEN PEACH APHID MORTALITY.

Oil	Percent for LC_{50}
Enclosed	
IP-2	20
P-5	21
N-4	21
Open	
IP-2	37
P-5	*
N-4	*

* Less than 50% mortality at 100% concentration.

Retzamine RAD 0500, Retzamine RAD 1100, and Retzaquat 47 were the most effective against both species listed (Table 5). Nine other surfactants and 1 oil and 2 other surfactants gave 90 to 100% mortality to weevil adults and red flour beetles, respectively. The data also show selective mortality as Retzloff DTG 62 gave 22 times greater mortality to the weevil than to the red flour beetle. One oil fraction (N-1) gave 182 times greater mortality to weevil adults than red flour beetles.

TABLE 5.—Surfactants and Oils for Mortality to Weevil and Red Flour Beetle.

Type	Name	Chemical name	Percent for LC_{50} Weevil	Red flour beetle
Amphoteric	Retzamine RAD 0500	Polyoxyethylated diethanolamine	*	*
Amphoteric	Retzamine RAD 1100	Polyoxyethylated diethanolamine	*	*
Anionic	Retzolate 58	Ammonium salt of a sulfated ethoxylated aliphatic alcohol	78	*
Anionic	Mentor Beads LD	Alkyl amine sulfonate	*	—
Anionic	Retzannate 65	Calcium sulfate	*	23
Anionic	Emcol E-607	Blend of oil soluble calcium sulfonate with polyethylene ethers	*	—
Anionic	Emcol G22-9	Blend of oil soluble calcium sulfonates with polyethylene ethers	77	63
Anionic	Retzannate 79	Alkanol amine sulfonate	88	54
Anionic	Daxad 27	Sodium salt of a substituted benzoid alkyl sulfonic acid	††	—
Anionic	Mentor Beads HG	Alkyl aryl sulfonate	††	—
Anionic	Daxad 21	Monocalcium salt of a polymerized alkyl aryl sulfonic acid	8	—
Anionic	High AI Mentor Beads	Alkyl aryl sulfonate	**	—
Anionic	Retzannate 93	Alkyl amine sulfonate	*	28
Anionic	Daxad 11	Polomerized sodium salts of alkyl naphthalene sulfonic acid	††	—
Anionic	Daxad 23	Sodium salts of polymerized substituted benzoid sulfonic acid	††	—
Anionic	Ultrawet DS	Alkyl benzene sodium sulfonate	12	—
Anionic	Orvus AB Granules	Sodium alkyl aryl sulfonate	2	—

(continued)

TABLE 5.—(continued)

Anionic	Mentor Beads LD	Alkyl aryl sulfonate	**	—
Cationic	Retzaquat 47	Quaternary ammonium salts	*	*
Cationic	Retzafoam 50	Sodium lauryl sulfate	*	**
Cationic	Emcol AD7-06	Blend of oil soluble calcium sulfate with polyethylene ethers	**	64
Cationic	Emcol E-12	Oil soluble calcium sulfonate and polyethylene ether blends	**	**
Cationic	Retzamide COA	Alkanolamides	**	**
Nonionic	Retzanol BA-70	Ethoxylated straight chain alcohol	*	63
Nonionic	Retzanol FA-012	Polyoxyethylene ester of fatty acid	27	35
Nonionic	Retzanol TD-815	Ethoxylated aliphatic	45	70
Nonionic	Retzanol M-139	Polyoxyethylene thioether	44	84
Nonionic	Retzloff DRA22	Alkyl aryl ethoxylated phenolic resin	41	57
Nonionic	Retzanol NP-100	Alkyl and polyether alcohol	66	**
Nonionic	Retzloff DRB203	High molecular weight oxyalkylated phenolic resin	*	44
Nonionic	Retzamide CD-60	Alkanolamides	88	66
Nonionic	Retzloff DTG62	High molecular weight polyol	53	**
Nonionic	Emgard 2050	Mixed alkylaryl and alkypolyoxyethylene glycols	58	*
Nonionic	Retzloff DGE60	High molecular weight polyether	72	84
Nonionic	Retzloff DPG-40	Oxyalkylated alkylene glycol esters	79	**
Nonionic	Triton X207	Octylphenyl polyethoxy ethanol	*	54
Nonionic	Retzamide LAX	Alkanolamide	**	**
Nonionic	Retzloff PNS254-B	Alkyl phenol formaldehyde polyoxyethyl ethanol	†	—
Nonionic	Tetronic 908	Propylene oxide + ethylene-diamine + ethylene oxide	††	—
Nonionic	Retzloff 50	Mixed fatty acid and oxyalkylated dinonyl phenol	**	—

(continued)

TABLE 5.—(continued)

Nonionic	Retzloff NS-29	Oxyalkylated tridecyl alcohol	49	—
Nonionic	Process R5162	Mixed alkyl + dialkyl phenol polyalkylene glycol ether	49	—
Nonionic	Ahco DD50	Alkyl benzyl trimethyl ammonium chloride	*	—
Nonionic	Ahco Base Oil 90	Oleic acid-ethylene oxide condensate	53	—
Nonionic	Igepal CO-630	Nonylphenoxypoly (ethyleneoxy) ethanol	**	—
Oil	N-1		52	**
Oil	***		*	—
Oil	P-1		56	**
Oil	Volck Supreme		10	—
Oil	IP-2		37	**
	Blood albumin		**	—

* 90-100% mortality at 10% concentration.
** Less than 50% mortality at 100% concentration.
*** A reformed aromatic stream with a boiling range of 350-450° F.
† 100% mortality at 40% concentration.
†† 0 mortality at 80% concentration.

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