TABLE I

BENZENESULFONYLUREAS R-C$_6$H$_4$-SO$_2$NHCONHR'

R	R'	M.p., °C.	Formula	Analyses, % Calcd. C	Calcd. H	Found C	Found H	Blood glucose, % change from controls after 2 hr.	4 hr.	6 hr.
CH_3CO	$(CH_2)_2C_6H_5$[a,e,j]	160	$C_{17}H_{18}N_2O_4S$	58.95	5.24	59.13	5.33	−8	0	0
C_2H_5CO	$CH_2C_6H_5$[a,e,i]	198–201	$C_{17}H_{18}N_2O_4S$	58.95	5.24	58.95	5.58	0	0	0
C_2H_5CO	$(CH_2)_2C_6H_5$[a,d,j]	137–138	$C_{18}H_{20}N_2O_4S$	59.98	5.60	60.10	5.85	+7	+9	+18
C_2H_5CO	n-C_6H_{13}[a,e,b,h]	131–134	$C_{16}H_{24}N_2O_4S$	56.45	7.11	56.55	7.13	+17	+23	+14
C_2H_5CO	cyclo-C_5H_{11}[b,e]	153–156	$C_{15}H_{20}N_2O_4S$	55.54	6.27	55.55	6.37	−24	−28	−28
C_2H_5CO	cyclo-$C_6H_{11}CH_2$[c,e]	178–179	$C_{17}H_{24}N_2O_4S$	57.94	6.87	58.18	6.90	−17	−17	−17
C_2H_5CO	cyclo-C_7H_{13}[a,e,g]	163–165	$C_{17}H_{24}N_2O_4S$	57.94	6.87	58.08	6.96	−4	−4	−4
C_4H_9CO	n-C_4H_9[a,e]	145	$C_{16}H_{24}N_2O_4S$	56.45	7.11	56.58	6.95	0	0	
C_4H_9CO	cyclo-C_6H_{11}[a,e]	187	$C_{18}H_{26}N_2O_4S$	59.62	7.23	59.47	7.23	0	0	
$Cl(CH_2)_3$	n-C_4H_9[a,d]	90	$C_{14}H_{21}ClN_2O_3S$	50.50	6.34	50.78	6.21	+12	+17	
$CH_3O(CH_2)_3$	n-C_4H_9[a,e]	80–82	$C_{15}H_{24}N_2O_4S$	54.83	7.38	54.94	7.25	+6	+13	
$CH_3O(CH_2)_3$	cyclo-C_6H_{11}[a,e]	136–138	$C_{17}H_{26}N_2O_4S$	57.59	7.39	57.54	7.34	−21	−22	−11
CN	n-C_4H_9[a,d,k]	181	$C_{12}H_{15}N_3O_3S$	51.20	5.38	50.91	5.36	+9	+13	
CN	cyclo-C_6H_{11}[a,e,k]	168–169	$C_{14}H_{17}N_3O_3S$	54.71	5.60	54.83	5.72	−23	−11	−12
C_2H_5CO	cyclo-C_6H_{11}[f]	183–185						−20	−33	−36
Tolbutamide								−29	−40	−40

[a] Prepared by method I. [b] Prepared by method II from ethyl-N-(4-propionylbenzenesulfonyl)carbamate (m.p. 103°) and cyclopentylamine. [c] Prepared by method II from ethyl-N-(4-propionylbenzenesulfonyl)carbamate and cyclohexylmethylamine. [d] Crystallized from 70% alcohol. [e] Crystallized from benzene. [f] For the preparation of this compound see footnotes 1 and 2. [g] Cycloheptyl isocyanate, b.p. 88–94° (20 mm.), was obtained from cycloheptylurea according to S. Rossi, A. Riva, and B. Piantamida, *Chim. Ind.* (Milan), **42**, 1243 (1960). [h] n-Hexyl isocyanate, b.p. 74–76° (20 mm.). [i] Benzyl isocyanate, b.p. 102° (20 mm.). [j] Phenethyl isocyanate, b.p. 50° (1 mm.). [h-j] Obtained according to C. F. H. Allen and A. Bell, "Organic Syntheses," Coll. Vol. III, New York, N. Y., 1955, p. 846. [k] p-Cyanobenzenesulfonamide was prepared according to E. Miller, J. M. Sprague, L. W. Kissinger, and L. F. McBurney, *J. Am. Chem. Soc.*, **62**, 2099 (1940).

p-Valerylbenzenesulfonamide was prepared from p-aminovalerophenone as described for p-butyrylbenzenesulfonamide. After crystallizing twice from water, white platelets, m.p. 110–112°, were obtained.

Anal. Calcd. for $C_{11}H_{15}NO_3S$: C, 54.73; H, 6.27. Found: C, 54.73; H, 6.39.

p-(Chloropropyl)benzenesulfonamide.—p-(Chloropropyl)benzenesulfonyl chloride, prepared from γ-chloropropylbenzene and chlorosulfonic acid, was converted to the sulfonamide with alcoholic ammonia. After three crystallizations from benzene a pure product, m.p. 77° was obtained.

Anal. Calcd. for $C_9H_{12}ClNO_2S$: C, 46.25; H, 5.18. Found: C, 46.30; H, 5.34.

p-(α-Methoxypropyl)benzenesulfonamide was prepared from γ-phenylpropyl methyl ether[9] as described for p-(γ-chloropropyl)-benzenesulfonamide and was crystallized from benzene, giving colorless crystals, m.p. 94°.

Anal. Calcd. for $C_{10}H_{15}NO_3S$: C, 52.36; H, 6.60; N, 6.11. Found: C, 52.59; H, 5.95; N, 6.15.

N-Arylsulfonyl-N'-alkylureas were prepared either from the arylsulfonamide and an alkyl isocyanate in the presence of potassium carbonate (method I) or from the carbamates and amines (method II) according to published procedures.[1-3]

Acknowledgment.—The author is indebted to Dr. M. Grotto and Dr. R. Horn for their interest and for the permission to publish this note.

(9) F. Strauss and A. Berkow, *Ann.*, **401**, 151 (1913).

Insect Chemosterilants. I. N-Acylaziridines

C. W. WOODS, A. B. BOŘKOVEC, AND F. M. HART

Entomology Research Division, U. S. Department of Agriculture, Beltsville, Maryland

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In recent years interest has grown in the chemistry of aziridines because of the antitumor or carcinostatic activity shown by many of these compounds. More recently it has been found that many of these compounds have the ability to cause sexual sterility in insects.[1] We wish to report the synthesis of a series of N-acylaziridines which were prepared to examine the effect of N-substitution on chemosterilant activity. It is remarkable that the synthesis of these compounds has not previously been reported,[2] since several references describing their antitumor or other properties may be found.[3,4]

The general method of preparation of the N-acylaziridines listed in Tables I and II consisted of reacting equivalent weights of the acid chloride with the appropriate aziridine using a sodium hydroxide solution to neutralize the hydrochloric acid formed in the reaction. Methylene chloride was found to be a convenient solvent and the temperature was held between −10 and 0° during the addition of the acid chloride. While this did not appear to be critical in the majority of reactions, it was found that a change of 15° in either direction led to greatly decreased yields of oxalyl- or malonylbisaziridine. The method used by Bestian[5] for the preparation of some ethyleneamides in which a halide was allowed to react with ethylenimine in the presence of triethylamine was also found applicable to the preparation of a number of our compounds, but in general led to lower yields and a less pure product.

The purification of the solid products by recrystallization presented no difficulty except when an alcohol was used; in such instances it was necessary to limit the heating to avoid reaction with the solvent. Distil-

(1) A. B. Bořkovec, *Science*, **137**, 1034 (1962).

(2) The synthesis of succinylbisaziridine (compound XIX, Table II) and glutarylbisaziridine has been reported by K. C. Tsou, K. Hoegerle, and H. C. F. Su, *J. Med. Chem.*, **6**, 435 (1963).

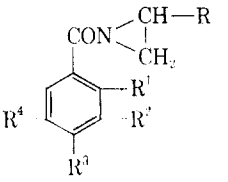
(3) J. A. Hendry, R. F. Homer, F. L. Rose, and A. L. Walpole, *Brit. J. Pharmacol.*, **6**, 357 (1951).

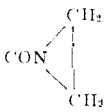
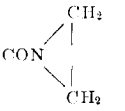
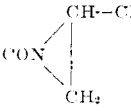
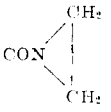
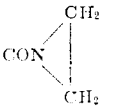
(4) T. H. Goodridge, W. T. Huntress, and R. T. Bratzel, *Cancer Chemotherapy Rept.*, **26**, 407 (1963).

(5) H. Bestian, *Ann. Chem.*, **566**, 210 (1950).

TABLE I

AROMATIC ACYLAZIRIDINES

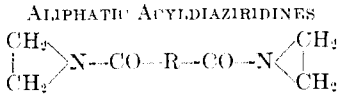


Compd.	R	R^1	R^2	R^3	R^4	Yield, %	B.p., °C. (mm.)	M.p., °C.	$n^{25}D$	—% nitrogen— Calcd.	Found	Recrystn. solvent
I	H	CH_3	H	H	H	81	75–80 (0.4)		1.5517	8.69	8.61	
II	H	H	CH_3	H	H	67	87–90 (0.4)		1.5515	8.69	8.82	
III	H	H	H	CH_3	H	62	85–90 (0.4)		1.5558	8.69	8.74	
IV	CH_3	CH_3	H	H	H	72	85–90 (0.4)		1.5375	8.00	7.94	
V	CH_3	H	CH_3	H	H	72	88–95 (0.4)		1.5377	8.00	8.06	
VI	CH_3	H	H	CH_3	H	60	92–97 (0.4)		1.5413	8.00	8.01	
VII	H	Cl	H	H	H	90			1.5698	7.71[a]	7.49[a]	
VIII	H	H	Cl	H	H	50		34–35		7.71	7.44	Pentane
IX	H	H	H	Cl	H	58		42–43[b]				Hexane
X	H	OCH_3	H	H	H	80				7.91	8.07	
XI	H	H	OCH_3	H	H	95				7.91	8.08	
XII	H	H	H	OCH_3	H	84		77–78		7.91	7.92	Cyclohexane
XIII	H	H		H	H	80		75–76.5		12.96	12.82	Benzene–cyclohexane
XIV	H	H	H		H	49		149–150.5		12.96	12.80	Benzene
XV	CH_3	H	H		H	41		111–115		11.47	11.65	Benzene
XVI	H	H		H		67		190 dec.		14.73	14.49	Methylene chloride

[a] *Anal.* Calcd.: Cl, 19.52. Found: Cl, 19.79. [b] H. W. Heine, M. E. Fetler, and E. M. Nickolson, *J. Am. Chem. Soc.*, **81**, 2202 (1959), report m.p. 42–44°.

TABLE II

ALIPHATIC ACYLDIAZIRIDINES



Compd.	R	Yield, %	M.p., °C.	—% carbon— Calcd.	Found	—% hydrogen— Calcd.	Found	—% nitrogen— Calcd.	Found	Recrystn. solvent
XVII	...	30	85–87	51.42	51.17	5.75	5.57	19.99	19.72	Methylene chloride
XVIII	CH_2		41–43	54.53	54.78	6.54	6.47	18.17	18.02	Methanol
XIX	$(CH_2)_2$	21	77–78	57.12	57.41	7.19	7.13			Benzene
XX	$(CH_2)_4$	51	39.5–40.5	61.20	60.96	8.22	8.16	14.28	14.43	Benzene–cyclohexane
XXI	$(CH_2)_5$	55	30–31	62.83	62.69	8.63	8.75			Cyclohexane
XXII	$(CH_2)_6$	30	46–48	64.25	64.09	8.99	8.83			Ethanol
XXIII	$(CH_2)_7$	38	49–51	65.51	65.43	9.31	9.38			Cyclohexane
XXIV	$(CH_2)_8$	71	58–59	66.63	66.57	9.59	9.64			Cyclohexane
XXV	CH:CH (*trans*)	43	123	57.82	57.65	6.07	6.11			Methylene chloride

lation of the liquid products was complicated by the tendency of the acylaziridines to isomerize to oxazolines.[6] This tendency was overcome in all but three reactions by rapid distillation at low pressure of small quantities of the material. It was not possible to distill benzoylaziridines having chloro or methoxy substituents on the phenyl ring.

The reaction of iso- and terephthaloyl chlorides with ethylenimine or 2-methylaziridine gave good yields of the diacylaziridines. Phthaloyl chloride, however, gave as an unexpected product N-(2-chloroethyl)phthalimide when it reacted with ethylenimine, or N-(2-chloropropyl)phthalimide with 2-methylaziridine.[7] This is undoubtedly the result of a rearrangement of the intermediate monosubstituted reaction product.

The compounds listed in Tables I and II were tested for their sterilizing properties by the entomologists of the Entomology Research Division, Agricultural Research Service, U. S. Department of Agriculture, toward house flies (*Musca domestica* L.), screw-worm flies [*Cochliomyia hominivorax* (Coquerel)], and Mexican fruit flies [*Anastrepha ludens* (Loew)].

(6) H. W. Heine, *Angew. Chem. Intern. Ed. Eng.*, **1**, 528 (1962).

(7) While this manuscript was in preparation the reaction between phthaloyl chloride and ethylenimine was reported by H. W. Heine, *J. Am. Chem. Soc.*, **85**, 2743 (1963).

The flies were allowed to feed on a diet containing 1% of the candidate chemosterilant and the sterilizing effect was determined from the extent of hatch of eggs which were periodically collected.[8] With the exception of compounds IV, V, VI, XV, and XVI, the remaining 20 compounds were active as chemosterilants toward at least one species of the insects. Additional tests with the active compounds at lower concentrations indicated that none of them was as effective as tepa or apholate.[8] Characteristically, the derivatives of 2-methylaziridine were all inactive.[9] Most surprising, however, was the lack of activity of the tris-aziridinyl XVI, especially because the related bis-aziridinyl XIII was active toward all three insect species.

Experimental[10]

General Method for Acylaziridines.—To a mixture of 8.6 g. (0.20 mole) of ethylenimine in 150 ml. of methylene chloride and 8.0 g. (0.20 mole) of sodium hydroxide in 50 ml. of water was added dropwise with moderate stirring 0.20 equiv. of the acid chloride. The temperature was maintained between −10° and 0° during the addition and then allowed to rise to 15° during a 1-hr. period. The organic layer was washed with a saturated sodium chloride solution, dried with magnesium sulfate, and the methylene chloride was removed by distillation under vacuum. The resulting product was either distilled or recrystallized when possible from the appropriate solvent. The physical constants and solvents are given in Table I.

1,1′-(1,2-Cyclobutanedicarbonyl)bisaziridine.—The 1,2-cyclobutanedicarbonyl chloride was prepared in the usual manner by allowing 14.4 g. (0.10 mole) of 1,2-cyclobutanedicarboxylic acid to react with 60 g. (0.50 mole) of thionyl chloride in 50 ml. of dry benzene. The yield of the dichloride was 16 g. (88%), b.p. 51° (0.2 mm.).

To 11 g. (0.25 mole) of ethylenimine in 100 ml. of methylene chloride and 6.7 g. (0.166 mole) of sodium hydroxide in 40 ml. of water was slowly added with stirring 15 g. (0.083 mole) of 1,2-cyclobutanedicarbonyl chloride in 75 ml. of methylene chloride. The temperature was held between −10 and 0° during the addition and allowed to rise to 20° during a 1-hr. period. The organic layer was dried with magnesium sulfate and the solvent removed by evaporation under vacuum to give 10 g. of a light green oil which was distilled, b.p. 100° (0.2 mm.), $n^{25}D$ 1.5180.

Anal. Calcd. for $C_{10}H_{14}N_2O_2$: N, 14.43. Found: N, 14.25.

N-(2-Chloroethyl)phthalimide.—To a mixture of 12.9 g. (0.30 mole) of ethylenimine in 150 ml. of methylene chloride and 12 g. (0.30 mole) of sodium hydroxide in 100 ml. of water was added slowly with stirring 30.5 g. (0.15 mole) of phthaloyl chloride in 360 ml. of methylene chloride. The temperature was maintained between −5 and 0° during the addition and allowed to rise to 12° within a 1-hr. period. The organic layer was dried with magnesium sulfate and the solvent was removed by evaporation under vacuum. The solid residue after two recrystallizations from methanol weighed 14 g. and melted at 81–82.5° (lit.[11] m.p. 81°).

Anal. Calcd. for $C_{10}H_8ClNO_2$: C, 57.29; H, 3.84; Cl, 16.92; N, 6.68. Found: C, 57.49; H, 3.86; Cl, 16.70; N, 6.41.

N-(2-Chloropropyl)phthalimide.—This compound was obtained in the same way as N-(2-chloroethyl)phthalimide except 2-methylaziridine was substituted for ethylenimine. From 0.30 mole of phthaloyl chloride was obtained, after recrystallization from methanol, 21 g. of product, m.p. 97–98° [N-(2-chloropropyl)phthalimide, lit.[12] m.p. 97.5–98; N-(1-chloro-2-propyl)-phthalimide, lit.[13] m.p. 56–58°].

Anal. Calcd. for $C_{11}H_{10}ClNO_2$: C, 59.07; H, 4.51; Cl, 15.85; N, 6.26. Found: C, 59.11; H, 4.56; Cl, 16.04; N, 6.24.

(8) Detailed procedures and results of the biological evaluation will be published elsewhere. For a description of methods used in comparative screening of chemosterilants, see H. K. Gouck, M. M. Crystal, A. B. Bořkovec, and D. W. Meifert, *J. Econ. Entomol.*, **56**, 506 (1963).

(9) A. B. Bořkovec and C. W. Woods, *Advan. Chem. Ser.*, **41**, 47 (1963).

(10) All melting points are corrected.

(11) H. Wenker, *J. Am. Chem. Soc.*, **59**, 422 (1937).

(12) L. Smith and B. Platon, *Ber.*, **55**, 3151 (1922).

(13) S. Gabriel and H. Ohle, *ibid.*, **50**, 812 (1917).

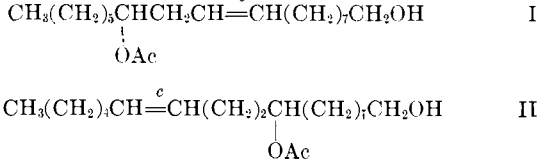
Insect Sex Attractants. V. The Synthesis of Some Additional Compounds Related to Gyplure

WILLIAM A. JONES AND MARTIN JACOBSON

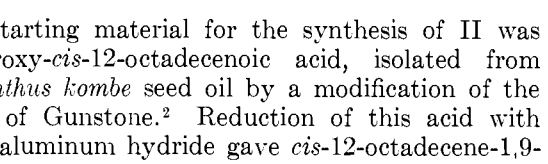
Entomology Research Division, Agricultural Research Service, United States Department of Agriculture, Beltsville, Maryland

Received November 29, 1963

In continuation of a program to synthesize compounds related to gyplure (*d*-12-acetoxy-*cis*-9-octadecen-1-ol)[1] (I), a potent sex attractant for the male gypsy moth (*Porthetria dispar*), we have prepared *d*-9-acetoxy-*cis*-12-octadecen-1-ol (II), as well as the *trans* form of I by a procedure different from that previously reported.[1]



I



II

The starting material for the synthesis of II was *d*-9-hydroxy-*cis*-12-octadecenoic acid, isolated from *Strophanthus kombe* seed oil by a modification of the method of Gunstone.[2] Reduction of this acid with lithium aluminum hydride gave *cis*-12-octadecene-1,9-diol, which was acetylated, with acetyl chloride in refluxing benzene containing pyridine, to the 1,9-diacetate. Saponification with one mole of ethanolic potassium hydroxide gave a product shown by gas chromatography to be 80% II and 20% of the 1,9-diol.

In contrast with the poor yield (28%) of the *trans* isomer of I obtained previously[1] by the nitrous acid elaidinization of gyplure, an over-all yield of 54% of the pure *trans* form was realized by subjecting ricinelaidyl alcohol[3] to acetylation and selectively saponifying the diacetate.

None of the compounds prepared elicited a typical sexual response from male gypsy moths when tested in the laboratory by the method of Block.[4,5] Although these substances are to be tested in field traps during male moth flight, their lack of activity in the laboratory makes it extremely unlikely that males will be attracted in the field.

The biological test results help to confirm the belief that, in compounds of this type, an acetoxy group situated in a position β to a *cis* double-bonded carbon is necessary for attractiveness to male gypsy moths.[1]

Experimental[6]

9-Hydroxy-*cis*-12-octadecenoic Acid.—Powdered *Strophanthus kombe* seed[7] (454 g.) was extracted in a Soxhlet extractor with

(1) M. Jacobson and W. A. Jones, *J. Org. Chem.*, **27**, 2523 (1962).

(2) F. D. Gunstone, *J. Chem. Soc.*, 1274 (1952).

(3) M. A. McCutchon, R. T. O'Connor, E. F. DuPré, L. A. Goldblatt, and W. G. Bickford, *J. Am. Oil Chemists' Soc.*, **36**, 450 (1959).

(4) B. C. Block, *J. Econ. Entomol.*, **53**, 172 (1960).

(5) These tests were conducted by Mr. C. Collier, Plant Pest Control Division, U. S. Department of Agriculture, Falmouth, Mass.

(6) Melting points are corrected; boiling points are uncorrected. Mention of trade names or proprietary products does not necessarily constitute endorsement by the Department of Agriculture.

(7) Obtained from S. B. Penick and Co., New York, N. Y.