

## The Development of Male Melon Fly Attractants

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The finding that anisylacetone [4-(*p*-methoxyphenyl)-2-butanone] was an effective lure for the male melon fly (*Dacus cucurbitae* Coq.) led to an investigation of related compounds, especially 4-aryl-2-butanones, to find better lures. The attractancy ratings of 119 compounds and their relationships between chemical structure and ability to lure are reported. Syntheses of many of the compounds and physical constants of the new ones are given. The best attractant, 4-(*p*-acetoxyphenyl)-2-butanone, now known as cue-lure, trapped more than 20 times as many flies as anisylacetone.

ALTHOUGH the melon fly (*Dacus cucurbitae* Coq.) is not known to occur on the mainland of the United States, it is found in Hawaii and in many other parts of the world. On several occasions, this economically serious pest (2) has been intercepted at ports of entry. With increasing travel and foreign trade, the possibility of accidentally importing the melon fly from Hawaii or elsewhere is a matter of continuing concern to the agricultural community. A more effective lure is needed to detect quickly any flies that may gain entry and become established. Such a lure should be highly specific, attractive over great distances, and, if possible, long-lasting (6, 15, 17, 23). Should an infestation become established, the lure would be invaluable in guiding eradication operations by indicating where and when insecticides should be applied. In just this way, attractants aided in the rapid elimination of the Mediterranean fruit fly [*Ceratitidis capitata* (Wied.)] in 1956 from the State of Florida (13, 32).

In 1957, Barthel and coworkers (3) reported that anisylacetone was an effective lure for the melon fly. In the search for better lures, compounds related to anisylacetone (7) were synthesized. Several of them, particularly cue-lure [4-(*p*-acetoxyphenyl)-2-butanone], were not only much more potent than anisylacetone, but also attractive to newly emerged flies. Under optimum Hawaiian climatic conditions, anisylacetone does not attract male melon flies until about 7 days after they emerge from pu-

pation, and then only after they approach or attain sexual maturity (7).

The search for an effective melon fly lure has been based on the same empirical approach that has resulted in the discovery of new insecticides, pharmaceuticals, and a host of other physiologically active substances. Briefly, many types of compounds were screened, and the structures of those exhibiting the greatest attraction were modified further to increase attractiveness. Although more than 3000 compounds were screened in this study, the attractiveness ratings of only 119—those most closely related to cue-lure—are reported here. Eighty-one of the reported compounds were synthesized in the Beltsville laboratories; the others were obtained from university or industrial sources.

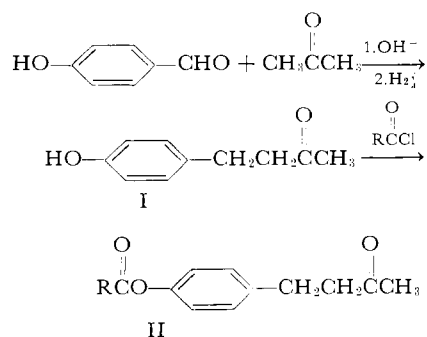
The finding of cue-lure, the most effective attractant in this study, illustrates the value of volume screening as a means of discovering new insect lures. Willison (34) found independently that the best lures described here also attract the Queensland fruit fly, *Dacus tryoni* (Froggatt).

### Preparation of Compounds

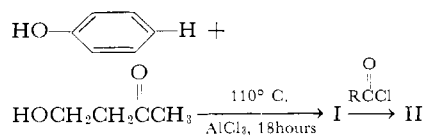
General procedures for the synthesis of the compounds are given and only the unusual or special chemical problems are described. Compounds previously reported are not discussed.

The 4-phenyl-2-butanones were prepared chiefly via the Claisen-Schmidt reaction and according to the general procedures described by Mannich (25) or Drake and Allen (17). The substituted benzaldehydes were reacted with the appropriate ketone in an alkaline medium,

and the products hydrogenated and when appropriate, acetylated.

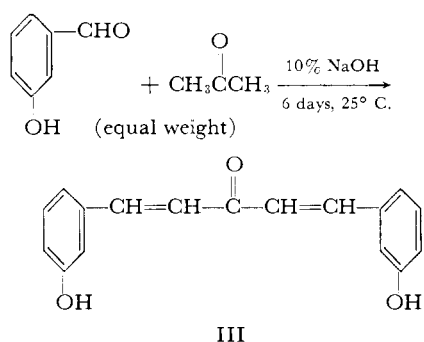


Some of the *p*-hydroxyphenyl compounds were synthesized by the reaction of a phenol with a hydroxyketone according to the directions of Maki and coworkers (24), whose procedure is a modification of that described earlier by Huston and Hedrick (20).

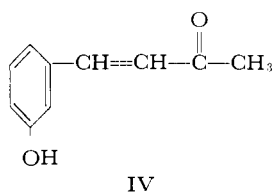


Since the Maki procedure gives only *p*-hydroxy-substituted compounds, the *o*-hydroxy analogs of I and II were made exclusively via the Claisen-Schmidt condensation. Difficulty was encountered, however, in the preparation of the corresponding *m*-hydroxy isomers by this route. *m*-Hydroxybenzaldehyde plus a large excess of acetone gave only unidentifiable tars; with an equal weight of the reactants, the dibenzylideneacetone (III) was obtained in good yield instead of the expected *m*-hydroxybenzylidene-

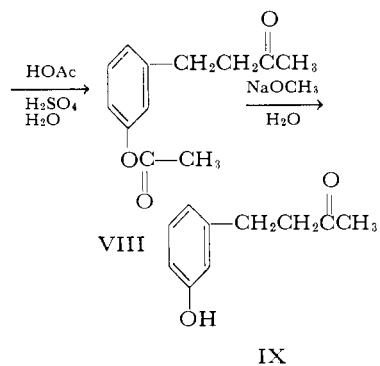
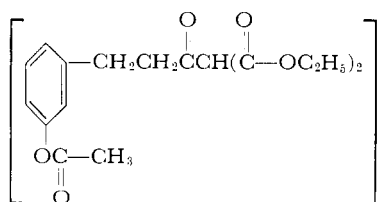
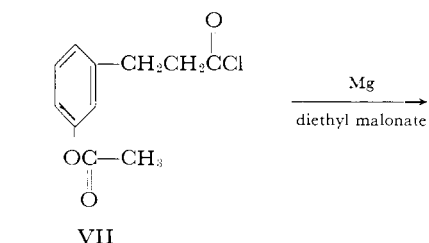
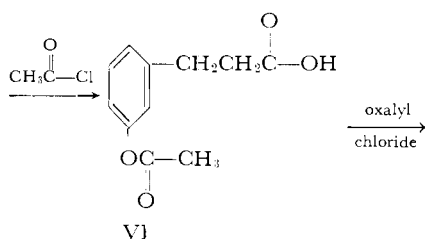
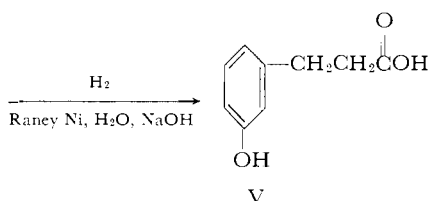
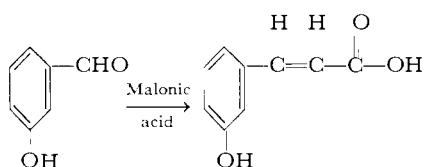
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acetone (IV). Since III was the prod-

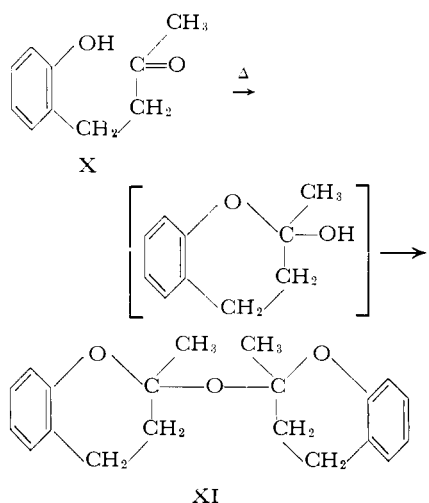


uct isolated, it was clear at this point why the meta-isomers of I and II had not been previously obtained via the Claisen-Schmidt procedure. These compounds were prepared, however, by the following sequence of reactions:



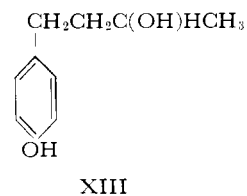
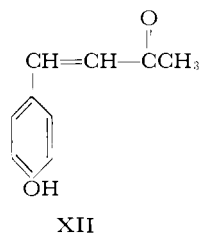
The synthesis of *m*-hydroxycinnamic acid from *m*-hydroxybenzaldehyde and malonic acid was accomplished via the Knoevenagel-Doebner reaction (27); however, in the ensuing hydrogenation step, a seldom-used method was superior to the authors' usual procedure. The authors previously hydrogenated the methyl ester of the acid and saponified it to get V; hydrogenation proceeded smoothly with high yield, but the saponification gave low yields. In hydrogenating the sodium salt (27) of *m*-hydroxycinnamic acid, hydrogenation proceeded as smoothly as with the methyl ester; treating the resultant sodium salt with a mineral acid avoided the saponification step, and V was obtained in much higher yield. Compound V was acetylated to protect the hydroxyl group. Oxalyl chloride (10) was utilized in the preparation of VII to avoid the possibility of removing the acetyl group and exposing a *m*-hydroxyl group which could give side-reaction products. The desired products VIII and IX were prepared from VII according to general directions already described (1, 28).

In reacting salicylaldehyde with acetone, then hydrogenating and distilling, care was taken in the distillation step to avoid cyclization and condensation of the product (X), to the hemiacetal or to the known bis(2-methylchromanyl) ether (XI) (5). In Beilstein (4), X, which was synthesized by Harries (18, 19), is erroneously shown as the hemiacetal.



Berlin, Sherlin, and Serebrennikova (5) distilled X at 15 mm. of Hg over a temperature of 85° to 150° C. and isolated XI (m.p. 95° C.); no yield was reported. The present authors distilled X at 105° C. (0.3 mm. Hg) and obtained not XI, but X, m.p. 48° to 50° C., in good yield. Although Berlin's work indicates that the hydroxy compound (X) could not be distilled at 15 mm. of Hg pressure without extensive ring closure, the authors found that its acetate could be distilled unaltered at this pressure. Deacetylation of the distillate with methanolic sodium methylate at room temperature gave the pure, uncyclized product in a good yield.

The finding that cue-lure (II, R = CH<sub>3</sub>) was the most effective attractant led to the consideration of problems related to its commercial synthesis. The Claisen-Schmidt condensation gave good yields of XII, but the hydrogenation (9) of this benzylidene intermediate always gave a mixture of the ketone (I) and about 15% of the alcohol (XIII).

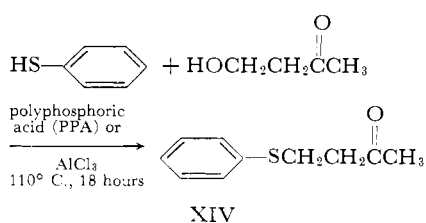


Field tests on the acetylated mixture disclosed, however, that the presence of the diacetate of this amount of the alcohol (XIII) depressed the attractive properties of cue-lure very little; the removal of the contaminant was therefore not worthwhile. In laboratory preparations, the ketone was readily freed of the alcohol contaminant (XIII) by making the bisulfite addition product and decomposing it with hydrochloric acid in the usual way.

The Maki reaction (24) previously mentioned gave a product with no alcohol contaminant, but yields from it were low. No attempt was made to improve yields, since Maki and coworkers had made a thorough study of the reaction under many different experimental conditions.

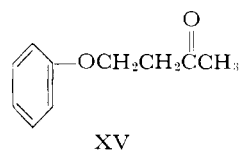
When certain substituted phenols were available and the corresponding aldehyde was not, or when substitution on the alkyl part of the molecule was desired, the Maki procedure was employed to prepare substituted *p*-hydroxyphenyl-2-butanones; yields were invariably poor.

When thiophenol was used in place of phenol in the Maki procedure, the thioether (XIV) was obtained in 90% yield (16).

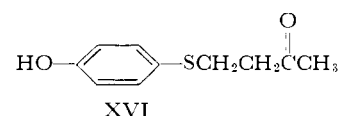
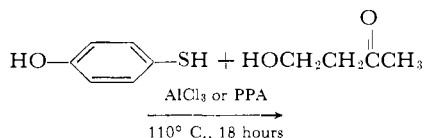


The use of phenol under the same conditions gave I, in 12 to 40% yield. In the latter reaction, some etherification to give XV undoubtedly takes place as a side reaction. Although pure XV

was not isolated, infrared data indicated its probable presence in some of the distillate fractions.



The high yield of XVI, prepared via the Maki reaction with *p*-monothiohydroquinone (26), was anticipated because the sulfhydryl is much more



acidic than the corresponding hydroxyl group. By way of illustration of the latter point, thiophenol (but not phenol) can be titrated to a sharp end point with sodium hydroxide and phenolphthalein as indicator (22).

The physical constants and yields of the new compounds prepared in this study are given in Table I.

**Screening.** The attractiveness rating is the ratio obtained by dividing the number of flies caught with the chemical by the number caught with the standard. Chemicals were first tested in Gow's

Table I. Physical and Chemical Data on New Compounds Tested as Melon Fly Attractants

R	Yield, %	B.P., °C./Mm. Hg	$n_D^{20}$ or M.P., °C.	Molecular Formula	Analyses			
					Carbon		Hydrogen	
					Calcd.	Found	Calcd.	Found
A. 4-Phenyl-2-Butanones R								
<i>m</i> -OH	75	87-88 (benzene)		C <sub>10</sub> H <sub>12</sub> O <sub>2</sub>	73.14	73.68	7.37	7.33
<i>m</i> -OCCH <sub>3</sub>	25	116-117/2	1.5051	C <sub>12</sub> H <sub>14</sub> O <sub>3</sub>	69.88	68.91	6.84	7.02
<i>p</i> -OCCH <sub>3</sub>	86	123-124/0.2	1.5061	C <sub>12</sub> H <sub>14</sub> O <sub>3</sub>	69.88	69.38	6.84	7.13
<i>p</i> -OCC <sub>3</sub> H <sub>7</sub>	77	120-125/0.1	1.4998	C <sub>14</sub> H <sub>18</sub> O <sub>3</sub>	71.77	71.64	7.74	7.96
<i>p</i> -OCC <sub>2</sub> H <sub>4</sub> CH(CH <sub>3</sub> ) <sub>2</sub>	86	120-145/0.1	1.4937	C <sub>15</sub> H <sub>20</sub> O <sub>3</sub>	72.55	71.95	8.12	8.29
-OCCH <sub>2</sub> Cl	83	142-148/0.3	1.5243	C <sub>12</sub> H <sub>13</sub> ClO <sub>3</sub>	59.88	59.89	5.44	5.64
<i>p</i> -OCCCl <sub>3</sub>	75	153-160/1	45 (ethanol)	C <sub>12</sub> H <sub>11</sub> Cl <sub>3</sub> O <sub>3</sub>	46.55	45.70	3.58	4.07
2-CH <sub>3</sub> ,4-OH	26	128-141/0.1	72-73 (benzene)	C <sub>11</sub> H <sub>14</sub> O <sub>2</sub>	74.13	73.34	7.92	8.26
3-CH(CH <sub>3</sub> ) <sub>2</sub> ,4-OH	34	124-131/0.1	46-47 (benzene and pentane)	C <sub>13</sub> H <sub>18</sub> O <sub>2</sub>	75.69	74.91	8.79	8.60
3,5-[CH(CH <sub>3</sub> ) <sub>2</sub> ] <sub>2</sub> ,4-OH	16	121-127/2	1.5187	C <sub>16</sub> H <sub>24</sub> O <sub>2</sub>	77.37	76.59	9.74	9.47
3-OCH <sub>3</sub> ,4-OCC <sub>2</sub> H <sub>5</sub>	62	130-136/0.2	1.5111	C <sub>14</sub> H <sub>18</sub> O <sub>1</sub>	67.18	66.90	7.25	7.42
3-C(CH <sub>3</sub> ) <sub>3</sub> ,4-OH	41	105-144/0.1	88-90 (toluene and pentane)	C <sub>14</sub> H <sub>20</sub> O <sub>2</sub>	76.32	76.04	9.15	9.19
B. Others 4-								
1-CH <sub>2</sub> CH <sub>2</sub> CH(CH <sub>3</sub> ) <sub>2</sub> OCH <sub>2</sub> ,4-OH	76	134-145/0.8	1.5139	C <sub>11</sub> H <sub>14</sub> O <sub>3</sub>	68.02	67.82	7.26	7.38
1-CH <sub>2</sub> CH <sub>2</sub> CH(OH)CH <sub>3</sub> ,4-OCCH <sub>3</sub>	48	111-120/0.2	1.5105	C <sub>12</sub> H <sub>16</sub> O <sub>3</sub>	69.21	68.68	7.75	7.81
1-OCH <sub>2</sub> CCH <sub>3</sub> ,4-Cl (28,35)	72	82-88/0.5	1.5352	C <sub>9</sub> H <sub>9</sub> ClO <sub>2</sub>	58.55	58.14	4.91	4.27
1-SCH <sub>2</sub> CH <sub>2</sub> CCH <sub>3</sub>	92	104-114/0.5	1.5617	C <sub>10</sub> H <sub>12</sub> OS	66.62	66.90	6.71	6.66
1-SCH <sub>2</sub> CH <sub>2</sub> CCH <sub>3</sub> ,4-OH	100		73-74 (benzene)	C <sub>10</sub> H <sub>12</sub> O <sub>2</sub> S	61.19	62.04	6.16	5.99
1-SCH <sub>2</sub> CH <sub>2</sub> CCH <sub>3</sub> ,4-OC-CH <sub>3</sub>	94		56-57 (ethanol)	C <sub>12</sub> H <sub>14</sub> O <sub>3</sub> S	60.48	60.56	5.92	6.19

olfactometer (14), which was used as previously described (8). Four chemicals (as 0.1% aqueous emulsions), each replicated three times, were tested simultaneously against a water standard.

Attractive chemicals were subjected

to a wick test (8). In this test a cotton dental roll containing the chemical and another with a standard lure were exposed for 15 minutes in the olfactometer. Counts were made of the flies lured to each when fresh and periodically as long

as the dental rolls attracted. Standards were changed as more effective lures were found; three were used: 4-(*p*-methoxyphenyl)-2-butanone (anisylacetone), 4-(*p*-hydroxyphenyl)-2-butanone, and 4-(*p*-acetoxyphenyl)-2-butanone (cue-lure). The wick test gave an indication of the lure's persistence.

**Field Tests.** The final test of a lure's acceptability is based on field evaluation. The candidates and a standard lure, each usually replicated 10 times, were exposed in Steiner traps (31, 32) in the insects' natural environment and counts of trapped flies recorded about twice a week. One per cent of the volatile insecticides DDVP or Dibrom (1,2-dibromo-2,2-dichloroethyl dimethyl phosphate) was included in each lure to kill the flies by fumigant action and one quarter teaspoon of a lindane-chlordan mixture was placed in the traps to prevent ants and spiders from carrying off the trapped flies.

**Results.** Olfactometer ratings and wick test results are given in Tables II to VII, field results in Table VIII. In Table VIII, the anisylacetone trap was baited with 5 grams, the other traps with 2 grams of lure.

### Discussion

The most accurate comparison of different chemical structures in terms of attraction would necessitate testing all of the chemicals in the field, where the most useful evaluations are made. Academically, such information would be interesting, but for practical reasons the authors' objective had to be limited to finding the best possible melon fly lure. The time necessary to conduct field tests on each compound could not be justified. Since all materials performing well in the olfactometer and wick tests were tried in the field, it is doubtful that any promising compounds of the 119 evaluated were missed. This leaves structure-activity comparisons somewhat incomplete among the less active materials, but not among the more active ones. However, the lack of data is offset somewhat by the fact that olfactometer, wick, and field tests do agree in a qualitative sense. Furthermore, some of the modifications in the basic 4-phenyl-2-butanone structure produced such marked changes in the product's activity that precise comparisons were unnecessary.

A consideration in the use of field data for structure-activity studies is the many environmental variables that may be encountered, such as temperature, humidity, wind conditions, sunlight, altitude, season, and flora available. The effects of the environmental variables are important and were studied ultimately on the few most effective lures, but they will not be dealt with in the primary studies detailed here.

**Table II. Attractiveness Ratings of 4-Phenyl-2-Butanones as Melon Fly Lures**

Compound No.	R	Olfactometer Rating	Wick Test	
			Std. <sup>a</sup>	% flies caught by std., days
1 (30)	H	28	4	10(0)
2	<i>p</i> -OH	20	3	400(0),125(1),100(2),75(6),75(13),50(24)
3	<i>p</i> -OCH <sub>3</sub> (anisylacetone)	33	..	..
4	<i>p</i> -OCCH <sub>3</sub> (cue-lure)	34	2	88(0),125(1),133(3),400(7),200(14),200(23)
5	<i>p</i> -OCCH <sub>2</sub> CH <sub>3</sub>	44	2	88(0),125(1),133(3),400(7),200(14),200(23)
6	<i>p</i> -OCCH <sub>2</sub> CH <sub>2</sub> CH <sub>3</sub>	48	2	125(0),133(1),167(3),500(7),200(14),200(23)
7	<i>p</i> -OCCH <sub>2</sub> CH(CH <sub>3</sub> ) <sub>2</sub>	28	2	5(0),0(1)
8	<i>p</i> -OCCH <sub>2</sub> Cl	45	2	100(0),150(1),250(4),200(7)
9	<i>p</i> -OCCHCl <sub>2</sub>	72	4	100(0),100(1),67(7),75(14),67(21),67(28)
10	<i>p</i> -OCCl <sub>3</sub>	65	4	100(0),50(1),67(7),75(14),67(21),67(28)
11	<i>p</i> -OCH <sub>2</sub> CH <sub>2</sub> OH	5	3	150(0),500(1)
12	<i>p</i> -OCH <sub>2</sub> CH <sub>2</sub> OCCH <sub>3</sub>	6	2	0(0),0(1)
13	3,4-(—OCH <sub>2</sub> O—)	31	..	..
14	2-CH <sub>3</sub> ,4-OH	26	4	8(0),13(1),42(7)
15	3-OCH <sub>3</sub> ,4-OH	21	2	50(0),63(1),100(3),100(7),100(14),100(21)
16	3-CH(CH <sub>3</sub> ) <sub>2</sub> ,4-OH	1	..	..
17	3-C(CH <sub>3</sub> ) <sub>3</sub> ,4-OH	2	..	..
18	3-C(CH <sub>3</sub> ) <sub>3</sub> ,4-OH,5-CH <sub>3</sub>	1	..	..
19	3,5-[CH(CH <sub>3</sub> ) <sub>2</sub> ] <sub>2</sub> ,4-OH	1	..	..
20	3,4-(OCH <sub>3</sub> ) <sub>2</sub>	1	..	..
21	3-OCH <sub>3</sub> ,4-OCCH <sub>3</sub>	5	2	17(0),0(1)
22	3-OCH <sub>3</sub> ,4-OCCH <sub>2</sub> CH <sub>3</sub>	4	2	15(0),40(1),100(4),100(7)
23	2-OH	1	3	0(0),0(1)
24	3-OH	32	4	13(1),15(3),15(5),25(7)
25	2-OCH <sub>3</sub>	62	3	60(0),50(1),35(4),80(6),50(11)
26	2-OCCH <sub>3</sub>	6	3	0(0),0(1)
27	3-OCCH <sub>3</sub>	25	4	13(1),15(3),25(5),25(7)
28	2,3-(OCH <sub>3</sub> ) <sub>2</sub>	1	..	..
29	4-Cl	12	..	..
30	2-CH <sub>3</sub>	7	..	..
31	4-CH <sub>3</sub>	24	..	..
32	4-CH(CH <sub>3</sub> ) <sub>2</sub>	20	3	0(0),0(1)
33 (.33)	4-N(CH <sub>3</sub> ) <sub>2</sub>	0.2	..	..
34	2,4-(CH <sub>3</sub> ) <sub>2</sub>	2	..	..

<sup>a</sup> Number under standard refers to compound number in left column—i.e., *p*-hydroxyphenyl-2-butanone is 2, anisylacetone 3, cue-lure 4.

**Table III. Attractiveness Ratings of 4-(*p*-Hydroxyphenyl)-2-butanol and Derivatives as Melon Fly Lures**

$$\text{R}-\text{C}_6\text{H}_4-\text{CH}_2\text{CH}_2\text{C}(\text{OH})\text{CH}_3$$

$$\text{R}'$$

Compound No.	R	R'	Olfactometer Rating	Wick Test		
				Std. <sup>a</sup>	% of flies caught by std., days	
35	—OH	—OH	15	2	100(0),100(1),100(2),100(6)	
36	—OH	—OCH	20	4	8(0),13(1),42(7)	
37	—OCH <sub>3</sub>	—OH	12	..	..	
38	—OCCH <sub>3</sub>	—OH	38	4	67(0),50(1)	
39	—OCCH <sub>3</sub>	—OCCH <sub>3</sub>	65	4	67(0),75(6),75(8)	

<sup>a</sup> See footnote, Table II.

**Table V. Attractiveness Ratings of Benzylidene Ketones as Melon Fly Lures**

$$\text{R}-\text{C}_6\text{H}_4-\text{CH}=\text{CH}-\text{C}(\text{O})\text{R}'$$

Compound No.	R	R'	Olfactometer Rating	Std. <sup>a</sup>	Wick Test	
					% of flies caught by std., days	
46	H	—CH <sub>3</sub>	11	..	..	
47	H	—C <sub>2</sub> H <sub>5</sub>	0	..	..	
48	H	—C <sub>3</sub> H <sub>7</sub>	0	..	..	
49	H	—CH(CH <sub>3</sub> ) <sub>2</sub>	0	..	..	
50	H	—OCH <sub>3</sub>	0.1	..	..	
51	H	—C <sub>6</sub> H <sub>5</sub>	3	..	..	
52	<i>p</i> -OH	—CH <sub>3</sub>	4	3	30(0),0(1)	
53(29)	<i>p</i> -OH	—OCH <sub>3</sub>	1	2	0(0),0(1)	
54	<i>p</i> -OCH <sub>3</sub>	—CH <sub>3</sub>	27	3	0(0),0(1)	
55	<i>p</i> -OCH <sub>3</sub>	—C <sub>2</sub> H <sub>5</sub>	4	..	..	
56	<i>p</i> -OCH <sub>3</sub>	—C <sub>3</sub> H <sub>7</sub>	11	..	..	
57	<i>p</i> -OCH <sub>3</sub>	—CH(CH <sub>3</sub> ) <sub>2</sub>	1	..	..	
58	<i>p</i> -OCH <sub>3</sub>	—CH <sub>2</sub> CH(CH <sub>3</sub> ) <sub>2</sub>	10	..	..	
59	<i>p</i> -OCH <sub>3</sub>	—C <sub>6</sub> H <sub>11</sub>	2	..	..	
60	<i>p</i> -OCH <sub>3</sub>	—C <sub>6</sub> H <sub>13</sub>	1	..	..	
61	<i>p</i> -OCH <sub>3</sub>	—COH(CH <sub>3</sub> ) <sub>2</sub>	3	..	..	
62	3,4(—OCH <sub>2</sub> O—)	—CH <sub>3</sub>	5	..	..	
63	3,4(—OCH <sub>2</sub> O—)	—C <sub>2</sub> H <sub>4</sub> COC <sub>2</sub> H <sub>5</sub>	3	..	..	
64	3,4(—OCH <sub>2</sub> O—)	—CH <sub>2</sub> COH(CH <sub>3</sub> ) <sub>2</sub>	1	..	..	
65	3,4(—OCH <sub>2</sub> O—)	—C <sub>6</sub> H <sub>5</sub>	4	..	..	
66	3,4(—OCH <sub>2</sub> O—)	— <i>p</i> -CH <sub>3</sub> C <sub>6</sub> H <sub>4</sub>	6	3	0(0),0(1)	
67	3,4(—OCH <sub>2</sub> O—)	— <i>p</i> -ClC <sub>6</sub> H <sub>4</sub>	0.5	..	..	
68	3,4(—OCH <sub>2</sub> O—)	— <i>p</i> -CH <sub>3</sub> OC <sub>6</sub> H <sub>4</sub>	10	3	0(0),0(1)	
69	3-OCH <sub>3</sub> ,4-OH	—CH <sub>3</sub>	1	..	..	
70	3-OCH <sub>3</sub> ,4-OCCH <sub>3</sub>	—CH <sub>3</sub>	1	..	..	
71	<i>o</i> -OH	—CH <sub>3</sub>	5	..	..	
72	<i>o</i> -OCH <sub>3</sub>	—CH <sub>3</sub>	1	..	..	
73	<i>o</i> -OCH <sub>3</sub>	—C <sub>2</sub> H <sub>5</sub>	0.2	..	..	
74	<i>o</i> -OCCH <sub>3</sub>	—CH <sub>3</sub>	0.06	5	0(0),0(1)	
75	<i>o</i> -CH <sub>3</sub>	—CH <sub>3</sub>	0	..	..	
76	2-OH,3-OCH <sub>3</sub>	—C <sub>2</sub> H <sub>5</sub>	5	..	..	
77	2-CH <sub>3</sub> ,4-CH <sub>3</sub>	—CH <sub>3</sub>	1	..	..	
78	<i>p</i> -CH(CH <sub>3</sub> ) <sub>2</sub>	—CH <sub>3</sub>	1	..	..	

<sup>a</sup> See footnote, Table II.

As may be seen from the data (Table VIII), the select compounds in this study were the 4-phenyl-2-butanones, para-substituted through an oxygen; the most effective of these in the field was the para-acetoxy analog (cue-lure).

Variations of the substituent(s) on the benzene ring of cue-lure are shown (Table II). Increasing the size of the acyloxy group (compare compound 4 with 5, 6, and 7) progressively decreased the compound's activity in the field,

**Table IV. Attractiveness Ratings as Melon Fly Lures of**

$$\text{R}-\text{C}_6\text{H}_4-\text{CH}_2\text{CH}_2\text{C}(\text{O})\text{R}'$$

Compound No.	R	R'	Olfactometer Rating
40	H	—C <sub>2</sub> H <sub>5</sub>	5
41	H	—C <sub>3</sub> H <sub>7</sub>	2
42	H	—CH(CH <sub>3</sub> ) <sub>2</sub>	3
43	<i>p</i> -OCH <sub>3</sub>	—C <sub>2</sub> H <sub>5</sub>	9
44	<i>p</i> -OCH <sub>3</sub>	—CH <sub>2</sub> CH(CH <sub>3</sub> ) <sub>2</sub>	9
45	<i>p</i> -OCH <sub>3</sub>	—C <sub>6</sub> H <sub>11</sub>	5

although laboratory test results did not follow this course. A possible reason why cue-lure appeared inferior to 4-(*p*-hydroxyphenyl)-2-butanone when fresh (Table II, compare wick test of compounds 2 and 4) was the necessity for diluting compound 2, a solid, with alcohol which resulted in its spreading over a larger area of the wick. Since compound 4 is a liquid, dilution was not necessary. This spreading probably increased the output of compound 2 during the first hour or so after application, but not thereafter. The mono-, di-, and trichloroacetates (compounds 8, 9, 10) did well in the laboratory, but were inferior to cue-lure in the field. Several other substituents placed on the aromatic ring were likewise found to provide inferior compounds. The ortho- and meta-substituted compounds (11 to 27) and those having chloro, alkyl, and *p*-dimethylamino substitutions (28 to 34) were inferior to cue-lure.

The *p*-hydroxy analog (compound 2) and 4-(*p*-hydroxyphenyl)-2-butanone (compound 35), their acetates (compounds 38 and 39), and a formate (compound 36) showed good activity (Table III). Replacing the carbonyl oxygen in the 2-butanone side chain with a hydroxy or an acetoxy group therefore does not appear to affect activity critically. Extending the length of the alkyl group attached to the carbonyl group of compounds 1 and 3 appears to decrease the activity of the parent compound (Table IV). The introduction of a double bond, alpha-beta to the phenyl ring, depresses activity markedly, since not one of the 33 compounds with this structure exhibited good attraction (Table V).

The chemicals (Table VI) present some interesting variations. Compound 79 is like 1, but has two methyl groups on the side chain; this change destroys its activity. Replacement of the methyl group of methyl ketones with an aryl (compare compounds 80 with 3, 81 with 13), hydroxyl (compare compound 82 with 2), or a methoxyl (compare compound 83 with 2) depressed activity. A shift of the carbonyl on the side chain so that it was alpha- or beta- to the ring

Table VI. Attractiveness Rating of Other Aryl Ketones as Melon Fly Lures

Compound No.	R	R	Olfactometer Rating	Wick Test	
				Std. <sup>a</sup>	% of flies caught by std., day
		$\begin{array}{c} \text{O} \\ \parallel \\ \text{R}-\text{CH}_2-\text{C}-\text{R}' \end{array}$			
79	C <sub>6</sub> H <sub>5</sub> -C(CH <sub>3</sub> ) <sub>2</sub> -	-CH <sub>3</sub>	0.1	..	..
80	<i>p</i> -CH <sub>3</sub> OC <sub>6</sub> H <sub>4</sub> CH <sub>2</sub> -	-C <sub>6</sub> H <sub>5</sub>	0.3	..	..
81	3,4(-OCH <sub>2</sub> O-)C <sub>6</sub> H <sub>3</sub> CH <sub>2</sub> -	<i>p</i> -CH <sub>3</sub> OC <sub>6</sub> H <sub>4</sub> -	2	..	..
82	<i>p</i> -HOC <sub>6</sub> H <sub>4</sub> CH <sub>2</sub> -	-OH	0.3	2	0(0)
83 (12)	<i>p</i> -HOC <sub>6</sub> H <sub>4</sub> CH <sub>2</sub> -	-OCH <sub>3</sub>	12	2	20(0),30(1),30(4),50(1)
84	<i>p</i> -CH <sub>3</sub> OC <sub>6</sub> H <sub>4</sub> -	-C <sub>2</sub> H <sub>5</sub>	20	3	0(0),0(1)
85	C <sub>6</sub> H <sub>5</sub> -	-C <sub>3</sub> H <sub>7</sub>	28	3	60(0),90(1),75(4),100(6), 50(8),0(11)
86	C <sub>6</sub> H <sub>5</sub> -	-CH <sub>2</sub> CH(CH <sub>3</sub> ) <sub>2</sub>	26	3	0(0),3(1)
87	C <sub>6</sub> H <sub>5</sub> -	-C <sub>4</sub> H <sub>9</sub>	6	3	6(0),15(1),0(4)
88	<i>p</i> -CH <sub>3</sub> OC <sub>6</sub> H <sub>4</sub> -	<i>p</i> -CH <sub>3</sub> OC <sub>6</sub> H <sub>4</sub> -	2	..	..
89	C <sub>2</sub> H <sub>5</sub> -	-C <sub>6</sub> H <sub>5</sub>	2	3	30(0),75(1),50(4),25(6),0(8)
90	CH <sub>3</sub> -	-C <sub>6</sub> H <sub>5</sub>	0.3	..	..
91	CH <sub>3</sub> -	<i>p</i> -HOC <sub>6</sub> H <sub>4</sub> -	0.1	..	..
92	CH <sub>3</sub> -	<i>p</i> -CH <sub>3</sub> OC <sub>6</sub> H <sub>4</sub> -	0	..	..
93	CH <sub>3</sub> -	<i>p</i> -CH <sub>3</sub> C <sub>6</sub> H <sub>4</sub> -	1	..	..
94	CH <sub>3</sub> -	$\begin{array}{c} \text{O} \\ \parallel \\ \text{p}-\text{CH}_3-\text{COC}_6\text{H}_4- \end{array}$	0.4	..	..
95	H	$\begin{array}{c} \text{O} \\ \parallel \\ \text{p}-\text{HOC}_6\text{H}_4\text{O} \end{array}$	0.3	..	..
96	H	$\begin{array}{c} \text{O} \\ \parallel \\ \text{p}-\text{CH}_3-\text{COC}_6\text{H}_4- \end{array}$	0.4	..	..
97	H	$\begin{array}{c} \text{O} \\ \parallel \\ \text{o}-\text{CH}_3\text{OC}_6\text{H}_4- \end{array}$	1	..	..
98	H	$\begin{array}{c} \text{O} \\ \parallel \\ \text{m}-\text{CH}_3\text{OC}_6\text{H}_4- \end{array}$	3	..	..
99	H	$\begin{array}{c} \text{O} \\ \parallel \\ \text{p}-\text{ClC}_6\text{H}_4\text{OCH}_2- \end{array}$	1	..	..
100	H	$\begin{array}{c} \text{O} \\ \parallel \\ \text{C}_6\text{H}_5\text{SCH}_2\text{CH}_2- \end{array}$	5	..	..
101	H	$\begin{array}{c} \text{O} \\ \parallel \\ \text{p}-\text{HOC}_6\text{H}_4\text{SCH}_2\text{CH}_2- \end{array}$	8	..	..
102	H	$\begin{array}{c} \text{O} \\ \parallel \\ \text{p}-\text{CH}_3-\text{COC}_6\text{H}_4\text{SCH}_2\text{CH}_2- \end{array}$	16	..	..
103	3,4(-OCH <sub>2</sub> O-)C <sub>6</sub> H <sub>3</sub> -	$\begin{array}{c} \text{O} \\ \parallel \\ \text{CH}_3- \end{array}$	4	..	..
104	<i>p</i> -ClC <sub>6</sub> H <sub>4</sub> O-	$\begin{array}{c} \text{O} \\ \parallel \\ -\text{OC}(\text{CH}_3)_2\text{CCH}_3 \end{array}$	1	..	..

<sup>a</sup> See footnote, Table II.

was also detrimental (compare compounds 84 and 3, 89 and 1). The introduction of a thioether in the molecule (compounds 100 to 102) was unrewarding. Other aryl ketones that proved inferior are listed (Table VI). The aliphatic methyl ketones (Table VII) had negligible action.

There are gaps in the structure-activity comparisons, but, as with testing of all chemicals, the evaluation of the complete series of every variation of each chemical structure is impractical. The authors made a limited number of modifications and followed them up with the preparation of compounds related to those that looked promising. Nevertheless, within this limit of operation it was possible to demonstrate which variations in the basic 4-phenyl-2-butanone structure are more or less critical in elevating, depressing, or destroying attraction for the melon fly.

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**Table VII. Attractiveness Ratings of Aliphatic Methyl Ketones as Melon Fly Lures**

Compound No.	R	Olfactometer Rating	Compound No.	Olfactometer Rating
105	$-\text{C}_3\text{H}_7$	1	115	0.4
106	$-\text{C}_2\text{H}_4\text{C}=\text{CH}_2$	3	116 <sup>a</sup>	6
107	$-\text{C}_2\text{H}_4\text{C}(\text{OC}_3\text{H}_7)$	1	117	4
108	$-\text{C}_2\text{H}_4\text{C}(\text{OCH}(\text{CH}_3)_2)$	2	118	0
109	$-\text{C}_2\text{H}_4\text{C}(\text{OCH}_2\text{CH}(\text{CH}_3)_2)$	2	119	0.1
110	$-\text{C}_2\text{H}_4\text{C}(\text{CHCH}_2\text{Cl})$	4		
111	$-\text{C}(\text{CH}_2\text{C}(\text{H})=\text{CCl})\text{C}(\text{O})\text{OC}_2\text{H}_5$	3		
112	$-\text{C}(\text{CH}_2\text{C}(\text{H})=\text{CCl})\text{C}(\text{O})\text{OC}_2\text{H}_5$	2		
113	$-\text{CH}_2$ (piperidine ring)	0		
114	$-\text{CH}_2$ (cyclohexane ring)	1		

<sup>a</sup> A wick test was run only on compound 116. It attracted less than 5% as many flies as *p*-hydroxyphenyl-2-butanone (compound 2).

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**Table VIII. Field Test Comparisons of Anisylacetone with the Most Attractive 4-Phenyl-2-butanones**

Compound No.	R	Total Number of Melon Flies Caught in 14 Days in Steiner Plastic Traps
3	$\text{CH}_3$ —(anisylacetone)	700
4	$\text{CH}_3\text{C}(\text{O})$ —(cue-lure)	16,000
5	$\text{CH}_3\text{CH}_2\text{C}(\text{O})$ —	10,000
2	H	8,000
6	$\text{CH}_3\text{CH}_2\text{CH}_2\text{C}(\text{O})$ —	6,000
7	$(\text{CH}_3)_2\text{C}(\text{H})\text{C}(\text{O})$ —	3,000

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## FUMIGANT MEASUREMENT

### The Coulometric Determination of Methyl Bromide

METHYL BROMIDE has been used extensively for fumigation of plants and plant products in railroad cars, warehouses, under tarpaulins, and in the holds of cargo ships. Under these conditions, large samples are available

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for methyl bromide determination, so that the concentration of the fumigant can be measured in the field by hot wire detectors (2) or by drawing samples into flasks containing monoethanolamine (5) and completing the analysis by volumetric or amperometric titration (1). Micro amounts of methyl bromide, however, found in the equipment used

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for fumigation research in these laboratories (4) require especially sensitive methods. In investigations of the penetration of methyl bromide into jute bales, an analytical method was required which was sensitive at the microgram level, rapid, and relatively simple. A large number of samples having methyl bromide concentrations