gave 168.1 g (77%) of *l* salt, mp 130–132°, $[\alpha]^{25}D$ −54.7° (*c* 16, H_2O). A sample was recrystallized from acetone (5 ml/g) with a recovery of 94%. It had mp 130–131° and $[\alpha]^{25}D$ −56.3° (*c* 15, H_2O). An additional 16.7 g of good product was recovered from the mother liquor by evaporation and treatment with hot methyl isobutyl ketone.

Anal. Calcd for $C_{21}H_{28}N_2O_2S_2$: N, 6.42; S, 14.66. Found: N, 6.02; S, 14.42.

d-(+)-6-Phenyl-2,3,5,6-tetrahydroimidazo[2,1-*b*]thiazole.—A solution of 150 g (0.344 mole) of *d*-(+)-**1** *d*-10-camphorsulfonate salt in water was treated with 15.5 g (0.378 mole) of 98% NaOH and the liberated base extracted ($CHCl_3$). The solution after washing (H_2O, NaCl) and drying ($MgSO_4$) was evaporated to give 72.1 g of product which had mp 60–61.5°, $[\alpha]^{25}D$ +85.1° (*c* 10, $CHCl_3$).

Anal. Calcd for $C_{11}H_{12}N_2S$: N, 13.71; S, 15.70. Found: N, 13.59; S, 15.79.

The base was dissolved in 112 ml of acetone and 178 ml of 3.8 *N* 2-propanolic HCl was added all at once. After cooling below 0°, the hydrochloride was recovered and washed with acetone; yield 72.2 g (0.312 mole, 91%), from the camphorsulfonate, mp 227–227.5°, $[\alpha]^{25}D$ +123.1° (*c* 15, H_2O).

Anal. Calcd for $C_{11}H_{13}ClN_2S$: N, 11.65; S, 13.31. Found: N, 11.56; S, 13.42.

l-(−)-**1** was prepared from the *d*-10-camphorsulfonate as described for the *d* compound. The free base had mp 60–61.5°, $[\alpha]^{25}D$ −85.1° (*c* 10, $CHCl_3$).

The hydrochloride, prepared by the method described for the *d* isomer, had mp 227–229°, $[\alpha]^{25}D$ −122.9° (*c* 15, H_2O).

Simultaneous Recovery of the Resolved *d*-(+)-Amine as the Hydrochloride and of the *d*-10-Camphorsulfonic Acid as the Racemic Amine Salt.—A solution of 4.37 g (0.010 moles) of *d*-(+)-6-phenyl-2,3,5,6-tetrahydroimidazo[2,1-*b*]thiazole *d*-10-camphorsulfonate in 10 ml of hot $CHCl_3$ was treated with 1.84 g (0.009 mole) of *dl*-base in 20 ml of toluene. The $CHCl_3$ was distilled and the crystalline product was washed with toluene. The salts weighed 4.27 g (9.8 mmoles, 98%), mp 194–196°, $[\alpha]^{25}D$ +21.7° (*c* 15, H_2O). The toluene filtrate, containing the liberated *d*-(+)-base was treated with 4 ml of 3.8 *N* 2-propanolic HCl. The hydrochloride was collected and washed with acetone. The yield was 2.16 g (99%), mp 226–228°, $[\alpha]^{25}D$ +122.5° (*c* 10, H_2O). The product is 98% optically pure *d*-(+)-**1** hydrochloride.

Simultaneous Recovery of the Resolved *l*-(−)-Amine as the Hydrochloride and of the *d*-10-Camphorsulfonic Acid as the Racemic Amine Salt.—A solution of 4.37 g (0.01 mole) of *l*-(−)-isomer *d*-10-camphorsulfonate was treated with 1.64 g (0.008 mole) of the *dl* base as described above. The recovered *d*-10-camphorsulfonate salt weighed 4.27 g (98%), mp 192–194°, $[\alpha]^{25}D$ 0° (*c* 10%, H_2O). The *l*-(−)-hydrochloride weighed 1.88 g (98%) and melted at 226–228°, $[\alpha]^{25}D$ −120°, indicating that the optical purity of the product was 97%.

Optically Pure Amine Salts from Optically Impure *d*-10-Camphorsulfonates.—A $CHCl_3$ solution from which the insoluble solvate had been filtered was calculated to contain 0.0443 mole of the *l*-amine and 0.0204 mole of the *dl*-amine *d*-10-camphorsulfonate salts. When this mixture was treated with 7.2 g (0.0353 mole) of the *dl*-amine, as detailed above, 97.5% of the *d*-10-camphorsulfonic acid was recovered as the complex racemic salt and the *l*-amine hydrochloride was recovered in 90% yield based on *dl*-base added and was 97% optically pure.

Purification of Optically Impure Amine by Crystallizing the *dl* Component as the *d*-10-Camphorsulfonate.—A solution of 8.9 g (0.0435 mole) of optically impure, $[\alpha]^{25}D$ −67.4°, 87.5% levo isomer, in approximately 25 ml of $CHCl_3$ was treated with 3.06 g (0.013 mole) of *d*-10-camphorsulfonic acid. Now 50 ml of toluene was added which caused a salt to precipitate within a few minutes. The $CHCl_3$ was distilled *in vacuo* and 50 ml of toluene was added. The insoluble *d*-10-camphorsulfonic acid salt weighed 4.90 g (0.012 mole), 92%, mp 189–192°, $[\alpha]^{25}D$ −7.5°. The toluene filtrate was treated with 2-propanolic HCl to precipitate the hydrochloride. The yield was 6.60 g (0.0274 mole), 84% of the theoretical *l*-amine available, mp 226–228°, $[\alpha]^{25}D$ −122.5° (*c* 12%, H_2O), 98% optically pure.

Resolution of *dl*-10-Camphorsulfonic Acid.—A warm solution of 32.3 g (0.138 mole) of *dl*-10-camphorsulfonic acid and 28.2 g (0.138 mole) of *d*-**1** in 180 ml of $CHCl_3$ was cooled to −10°. The separated salt was recovered and washed with $CHCl_3$. This material, $[\alpha]^{25}D$ +79.6° (*c* 20% in water), was recrystallized from $CHCl_3$ to yield 22.7 g (75.6%), $[\alpha]^{25}D$ +83.9°. The *d*-10-camphorsulfonic acid was recovered in the form of its ammonium salt by partitioning the salt between $CHCl_3$ and NH_4OH and evaporating the aqueous layer. A sample of the ammonium salt, 24.9 g (0.1 mole), was added to 50 ml of AcOH, and 10 g (0.1 mole) of H_2SO_4 was added. $(NH_4)HSO_4$ was removed and the filtrate evaporated to dryness. Extraction of the residue with 100 ml of hot $MeNO_2$ and cooling gave 9.6 g of the sulfonic acid, mp 198°, $[\alpha]^{25}D$ +22.1° (*c* 12% in water). An additional 7.0 g of pure acid was recovered from the mother liquor; total recovery 71.5%. *l*-10-Camphorsulfonic acid prepared by essentially the same method had mp 196–200° and $[\alpha]^{25}D$ −21.3° (*c* 13%, H_2O).

Racemization with Potassium *t*-Butylate without Solvent.—A mixture of 200 mg of *d*-(+)-**1** and 50 mg of potassium *t*-butoxide was heated in an oil bath at 100° for 2 hr. The product was partitioned between CH_2Cl_2 and water. The optical rotation of the dried (K_2CO_3) CH_2Cl_2 layer was 0°. The hydrochloride was prepared from acetone by adding 2-propanolic HCl. The yield was 145 mg (62%) of *dl*-**1** hydrochloride, mp 262°.

Racemization with Sodamide in DMSO.—About 0.5 g of $NaNH_2$ was dissolved in 25 ml of DMSO and 1 ml of this solution was added to 1 g of *d*-(+) isomer in 8 ml of DMSO. The rotation of the solution was 0° in a few minutes. The reaction mixture was poured into H_2O and extracted with $CHCl_2$. $CHCl_2$ extract was washed (H_2O), dried (K_2CO_3), and evaporated leaving 0.6 g of *dl*-**1**, mp 87–89°, hydrochloride mp 264–265°.

Synthesis and Herbicidal Activity of 1,1-Dimethyl- and 2-Methyl-4-phenylsemicarbazides[1]

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Certain 1,1-dialkyl-3-phenylureas are potent herbicides,[2] due in part to their ability to inhibit the Hill reaction of photosynthesis.[3] The corresponding monoalkylureas differ but little in herbicidal activity[4] or inability to inhibit the Hill reaction.[3d] In studies of the relationship between structure, herbicidal activity, and inhibition of the Hill reaction, it seemed desirable to prepare the title compounds. In spite of the close structural similarity of the title compounds to phenylurea herbicides, no published reference to their activity as inhibitors of the Hill reaction or as herbicides has been found.

The compounds listed in Table I were dissolved in methanol and applied preemergence (10 lb/acre) to *Zea mays* L. (Coker 67 field corn), *Lolium multiflorum* Lam. (Italian ryegrass), *Lactuca sativa* L. (Great Lakes lettuce), *Lycopersicon esculentum* Mill. (Rutgers tomato), and *Brassica juncea* (L.) Coss. (Florida broadleaf mustard) which had been planted in greenhouse flats.

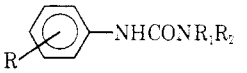
(1) Florida Agricultural Experiment Station Journal Series 2754.

(2) H. C. Bucha and C. W. Todd, *Science*, **114**, 493 (1951); C. W. Todd, U. S. Patent 2,655,446 (1953); B. R. Anderson, V. C. Bachman, S. R. McLane, and E. W. Dean, *Weeds*, **5**, 135 (1957); CIBA Ltd., British Patent 899,718 (1962); *Chem. Abstr.*, **58**, 1400 (1963); J. U. Simonian, H. Kroll, and J. B. Peterson, U. S. Patent 3,205,258 (1965).

(3) (a) A. R. Cooke, *Weeds*, **4**, 397 (1956); (b) J. S. C. Wessels and R. Vander Veen, *Biochim. Biophys. Acta*, **19**, 548 (1956); (c) D. E. Moreland, K. L. Hill, and J. L. Hilton, *Abstr. Weed Soc. Am.*, **2**, 40 (1958); (d) N. E. Good, *Plant Physiol.*, **36**, 788 (1961).

(4) C. W. Todd, U. S. Patent 2,655,447 (1953).

TABLE I
PHENYLSEMICARBAZIDES



No.	R	R_1	R_2	Recrystn solvent[a]	Mp, °C	Formula	Carbon, % Calcd	Carbon, % Found	Hydrogen, % Calcd	Hydrogen, % Found	N or other, % Calcd	N or other, % Found
1	H	H	$N(CH_3)_2$	B	111.5–112[b]	$C_9H_{13}N_3O$	60.31	60.40	7.31	7.27		
2	H	CH_3	NH_2	M, D, A	90–92.5[c]	$C_8H_{11}N_3O$						
3	H	H	c-$N(CH_2)_6$	A, B, M	102.5–103	$C_{13}H_{19}N_3O$	66.92	66.70	8.21	8.25		
4	2-Cl	H	$N(CH_3)_2$	M, L	88.5–89.5[d]	$C_9H_{12}ClN_3O$	50.59	50.77	5.66	5.77		
5	2-Cl	CH_3	NH_2	M, L	100–101	$C_8H_{10}ClN_3O$	48.13	48.36	5.05	5.14	17.76[e]	17.39[e]
6	3-Cl	H	$N(CH_3)_2$	L, M	98–99.5[f]	$C_9H_{12}ClN_3O$						
7	3-Cl	CH_3	NH_2	M, A, C	158–160.5	$C_8H_{10}ClN_3O$	48.12	48.36	5.05	5.15	17.77[e]	18.06[e]
8	4-Cl	H	$N(CH_3)_2$	L, A	150–151.5[g]	$C_9H_{12}ClN_3O$	50.59	50.22	5.66	5.53	16.60[e]	16.25[e]
9	4-Cl	H	c-$N(CH_2)_6$	C	150.5–152	$C_{13}H_{18}ClN_3O$	58.31	58.14	6.78	6.51		
10	3,4-Cl_2	H	$N(CH_3)_2$	B	132–133.5	$C_9H_{11}Cl_2N_3O$	43.56	43.58	4.47	4.59		
11	3,4-Cl_2	CH_3	NH_2	M, A, D, L	137.5–139	$C_8H_9Cl_2N_3O$	41.04	40.87	3.88	3.83	30.29[e]	30.06[e]
12	3,4-Cl_2	H	c-$N(CH_2)_6$	C, B	155–156	$C_{13}H_{17}Cl_2N_3O$	51.66	51.70	5.67	5.61		
13	4-F	H	$N(CH_3)_2$	A, L, B	121–122	$C_9H_{12}FN_3O$	51.81	51.95	6.13	6.09		
14	4-Br	H	$N(CH_3)_2$	L, M	153.5–154.5	$C_9H_{12}BrN_3O$	41.88	41.72	4.69	4.67	30.96[f]	30.15[h]
15	4-Br	CH_3	NH_2	A, M	153–155	$C_8H_{10}BrN_3O$	39.36	39.56	4.13	4.14		
16	2-CH_3	H	$N(CH_3)_2$	M	142–143	$C_{10}H_{15}N_3O$	62.15	62.09	7.82	7.75	21.75	22.02
17	2-CH_3	CH_3	NH_2	M	101.5–102.5	$C_9H_{13}N_3O$	60.31	59.21	7.31	7.10	23.45	23.99
18	3-CH_3	H	$N(CH_3)_2$	L, M	78–79	$C_{10}H_{15}N_3O$	62.15	62.35	7.82	7.99	21.75	21.60
19	3-CH_3	CH_3	NH_2	D, L	91–92.5	$C_9H_{13}N_3O$	60.31	60.10	7.31	7.18	23.45	23.20
20	4-CH_3	H	$N(CH_3)_2$	L, M, A	136–137	$C_{10}H_{15}N_3O$	62.15	62.01	7.82	7.78	21.75	21.49
21	4-CH_3	CH_3	NH_2	L	141–143.5	$C_9H_{13}N_3O$	60.31	60.68	7.31	7.21	23.45	23.22
22	2-NO_2	H	$N(CH_3)_2$	M	143–145	$C_9H_{12}N_4O_3$	48.21	48.45	5.40	5.54	24.99	25.15
23	2-NO_2	CH_3	NH_2	M, A, C	148.5–149	$C_8H_{10}N_4O_3$	45.71	45.75	4.80	4.95	26.66	26.80
24	3-NO_2	H	$N(CH_3)_2$	M, L	142.5–143.5	$C_9H_{12}N_4O_3$	48.21	47.97	5.40	5.34	24.99	24.80
25	3-NO_2	CH_3	NH_2	M, A, C	150–152	$C_8H_{10}N_4O_3$	45.71	45.85	4.80	4.91	26.66	26.90
26	4-NO_2	H	$N(CH_3)_2$	M, A	206–206.5	$C_9H_{12}N_4O_3$	48.21	47.98	5.40	5.43	24.99	24.80
27	4-NO_2	CH_3	NH_2	M	195–196.5	$C_8H_{10}N_4O_3$	45.71	45.92	4.80	4.80	26.66	26.40
28	4-OCH_3	H	$N(CH_3)_2$	L, D	123–124	$C_{10}H_{15}N_3O_2$	57.40	57.31	7.23	7.33	20.08	19.85
29	4-OCH_3	CH_3	NH_2	L	105–106	$C_9H_{13}N_3O_2$	55.37	55.55	6.71	6.69	21.53	20.99

[a] Solvents: A = EtOAc–ligroin, B = Me_2CO–ligroin, C = $CHCl_3$–ligroin, D = Et_2O–MeOH–ligroin, E = aqueous EtOH, L = Et_2O–ligroin, M = aqueous MeOH. [b] R. S. Levy [*Mem. Poudres*, **40**, 429 (1958); *Chem. Abstr.*, **55**, 19839 (1961)] reported mp 108°. [c] M. Busch, E. Opfermann, and H. Walther [*Chem. Ber.*, **37**, 2324 (1904)] reported mp 93–94°. [d] Lit.[b] mp 96°. [e] Cl analysis. [f] Lit.[b] mp 99°. [g] Lit.[b] mp 138°. [h] Br analysis.

Untreated controls, methanol-treated controls, and standards treated with the herbicide 3-(3,4-dichlorophenyl)-1,1-dimethylurea (diuron) or 2-chloro-4-ethylamino-6-isopropylamino-*s*-triazine (atrazine) at 10 lb/acre were also included. Plants treated with diuron or atrazine showed phytotoxic symptoms within 5 days. After 7 weeks all plants were dead in the diuron-treated flats, and only *Zea mays* survived in the atrazine-treated flats. The plants in flats treated with compounds in Table I showed no symptoms of phytotoxicity during this period.

Experimental Section[5]

4-Phenylsemicarbazides.—The appropriate phenyl isocyanate was dissolved in 5 vol of dry ethyl ether if liquid, or if a solid, in 10 vol of toluene at 45° and added slowly to 1.1 equiv of the appropriate alkylhydrazine in 30 vol of dry Et_2O at room temperature. The crude product usually precipitated in approximately quantitative yield within a few minutes, except 2-chlorophenyl and 2-tolyl analogs, which required concentration of solvent. The crude product was filtered off and recrystallized as indicated in Table I.

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(5) Melting points were determined by means of a Kofler micro hot stage and are corrected. The elemental analyses were performed by Drs. G. Weiler and F. Strauss, Microanalytical Laboratory, Oxford, England.

5-Aryl-1,5-dihydro-2H-1,4-benzodiazepin-2-ones[1a]

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Considerable therapeutic importance attaches to several representatives of the 1,4-benzodiazepine ring system.[1b] Four such compounds (chlordiazepoxide, I; diazepam, II; oxazepam, III; and nitrazepam, IV) are employed clinically for their effects on the central nervous system, and many others have undergone testing. The benzodiazepines thus resemble the phenothiazine tranquilizers in the breadth of structural variation that is possible without loss of pharmacological activity.

All of the marketed compounds have a >C=N– system between positions 4 and 5 (I N-oxide), but published reports indicate that saturation of this bond does not destroy activity.[1b] We wished to examine the effects of shifting the unsaturation from the 4,5 to the 3,4 positions and have developed methods for preparing the desired 1,5-dihydro-2H-1,4-benzodiazepin-2-ones. The chemical reactions of these products have been

(1) (a) Presented in part at the 152nd National Meeting of the American Chemical Society, New York, N. Y., Sept 1966; (b) S. J. Childress and M. I. Gluckman, *J. Pharm. Sci.*, **53**, 577 (1964).