



Fig. 1.—Individual activity coefficients of ions: drawn lines represent calculated values, with rounded  $a_i$ ; — figures given in Table I.

TABLE III

Electrolyte	Ionic concn. $\Gamma$	Mean ionic activity coefficient				
		Exptl.	Table II	Approx. formula	Guggenheim formula	Lewis-Randall tables
HI	0.01	0.927	0.928	0.927	0.927	0.95
	.02	.902	.906	.90	.90	.92
	.04	.870	.875	.865	.865	.895
	.1	.822	.83	.81	.81	.86
	.2	.787	.79	.76	.76	.815
HCl	.01	.928	.928	.927	.927	.95
	.02	.905	.906	.90	.90	.92
	.04	.878	.875	.865	.865	.895
	.1	.831	.83	.81	.81	.86
	.2	.799	.79	.76	.76	.815
HCl in LaCl <sub>3</sub>	.125	.818	.82	.795	.795	.85
	.15	.811	.81	.78	.78	.84
	.175	.794	.80	.77	.77	.825
NH <sub>4</sub> NO <sub>3</sub>	.02	.882	.898	.90	.90	...
	.04	.840	.865	.87	.87	...
	.1	.783	.80	.81	.81	...

	.2	.726	.75	.76	.76	...
	.4	.658	.69	.70	.70	...
	1.0	.59	.605	.62	.62	...
LiC <sub>7</sub> H <sub>7</sub> SO <sub>3</sub>	0.04	.877	.88	.875	.87	...
	.25	.782	.785	.77	.74	...
	1.0	.703	.71	.675	.62	...
HCOONa	0.004	.954	.955	.953	.953	...
	.01	.931	.927	.927	.927	...
	.02	.908	.901	.90	.90	...
	.04	.879	.87	.865	.865	...
Li <sub>2</sub> SO <sub>4</sub>	.012	.862	.85	.855	.85	.82
	.03	.808	.78	.79	.78	.75
	.06	.754	.725	.73	.71	.70
	.3	.601	.57	.58	.525	...
ZnCl <sub>2</sub>	.01	.857	.861	.865	.86	.845
	.03	.778	.78	.79	.78	.77
	.1	.660	.68	.685	.66	.67
	.17	.609	.63	.63	.59	.62
	.5	.51	.53	.53	.465	...
La(NO <sub>3</sub> ) <sub>3</sub>	.0145	.796	.785	.785	.765	.79
	.034	.720	.71	.71	.675	.72
	.066	.645	.645	.645	.59	.64
	.118	.570	.59	.59	.51	.57
	.221	.505	.525	.525	.42	.50
K <sub>3</sub> Fe(CN) <sub>6</sub>	.012	.785	.79	.79	.78	.82
	.024	.717	.72	.73	.71	.76
	.06	.618	.61	.63	.60	.69
	.12	.547	.52	.55	.51	.62

### Summary

Individual activity coefficients of 130 inorganic and organic ions in water at concentrations up to  $\Gamma = 0.2$  have been computed and tabulated; parameters  $a_i$  were calculated by various methods. For approximative work, these individual figures have been shown to give mean coefficients in sufficient accordance with experimental values.

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## Constituents of Pyrethrum Flowers. IX. The Optical Rotation of Pyrethrolone and the Partial Synthesis of Pyrethrins<sup>1</sup>

BY H. L. HALLER AND F. B. LAForge

Among the observations on the chemical and physical properties of tetrahydropyrethrolone, we have previously reported its specific rotation as  $+11.9^\circ$ .<sup>2</sup> This value agrees in magnitude but differs in sign from the one ( $-11.3^\circ$ ) reported by Staudinger and Ruzicka<sup>3</sup> for the same compound.

The material on which their rotation is reported was prepared by hydrogenation of a pyrethrolone preparation obtained from a mixture of the semicarbazones of pyrethrins I and II in which the relative proportions of each were unknown.

(1) For Article VIII of this series, see *J. Org. Chem.*, **2**, 56 (1937).  
 (2) LaForge and Haller, *THIS JOURNAL*, **58**, 1777 (1936).  
 (3) Staudinger and Ruzicka, *Helv. Chim. Acta*, **7**, 212 (1924).

Since the rotation reported by us was also observed on material originating from a mixture of both pyrethrins, the discrepancy between our value and that reported by Staudinger and Ruzicka might be explained with the assumption that the pyrethrolone present in pyrethrin I differed optically from the one in pyrethrin II.

We have previously described a method<sup>4</sup> by which pyrethrin concentrates may be separated into fractions in each of which one of the pyrethrins predominates. From a fraction in which pyrethrin I predominates its semicarbazone may

(4) LaForge and Haller, *THIS JOURNAL*, **57**, 1893 (1935).

be obtained in a state of at least approximate purity, and from a fraction that is largely pyrethrin II its pure semicarbazone may be obtained.

The semicarbazones of the pyrethrolones have now been prepared from the semicarbazones of each of the pyrethrins. The semicarbazone of pyrethrolone obtained from pyrethrin I semicarbazone melted with decomposition at 206°; that obtained from pyrethrin II at 212°. The two semicarbazones were then hydrolyzed in the manner previously described,<sup>5</sup> and the pyrethrolones isolated and distilled. Both boiled under the same conditions at the same temperature. The pyrethrolone from pyrethrin I showed a specific rotation of +14.85°, that from pyrethrin II +17.7°. Both preparations showed the same refractive index.

The slight differences in the melting points of the semicarbazones and in the specific rotations of the pyrethrolones may be explained by partial racemization. It can be concluded therefore that the pyrethrolones from the two sources are identical.

Attention may be called again to the fact that we have obtained a chemically pure pyrethrin II<sup>2</sup> by distillation of a concentrate but that no crystalline semicarbazone could be obtained from this material, and that distilled pyrethrin I yielded only 50% of crystalline semicarbazone. These results may be explained on the basis of optical changes in the molecule, for which there are theoretically many opportunities.

Staudinger and Ruzicka have prepared both pyrethrins by esterification of pyrethrolone with the acid chlorides of chrysanthemum monocarboxylic acid and chrysanthemum dicarboxylic acid monomethyl ester. These synthetic pyrethrins are reported to be very toxic and their composition is indicated by analysis, but neither yielded satisfactory semicarbazones. Since some change evidently takes place when natural pyrethrin II is distilled, it seemed possible that failure to obtain crystalline semicarbazones was due to some change caused by distillation.

The semicarbazone of pyrethrin II has been shown to be obtained easily in a pure state. We have therefore repeated the synthesis of pyrethrin II according to the method of Staudinger and Ruzicka with the employment of pyrethrolone obtained from both pyrethrin I and pyrethrin II. In both instances the synthetic py-

rethrins consisted of light yellow oils which were not distilled but treated directly with semicarbazide in the usual manner. Neither yielded a crystalline semicarbazone. It seemed possible that, in addition to optical relations, the presence of the combination of double bonds in the side chain of pyrethrolone might complicate the reaction with the acid chlorides. Tetrahydropyrethrolone therefore was treated with the acid chloride of chrysanthemum dicarboxylic acid monomethyl ester with the object of obtaining tetrahydropyrethrin II, which had already been prepared<sup>5</sup> by hydrogenation of pyrethrin II, and which also had been shown to yield a satisfactory crystalline semicarbazone. The product of this synthesis when treated with semicarbazide yielded a crystalline semicarbazone identical with the semicarbazone of tetrahydropyrethrin II obtained by hydrogenation of natural pyrethrin II. Tetrahydropyrethrolone also was esterified by treatment with the acid chloride of chrysanthemum monocarboxylic acid, and this product likewise yielded a crystalline semicarbazone which analyses indicated to be tetrahydropyrethrin I semicarbazone. The melting point, however, was lower than that of a crystalline product obtained by hydrogenation of pyrethrin I semicarbazone.

### Experimental

**Pyrethrolone from Pyrethrin I Semicarbazone.**—The semicarbazone of pyrethrin I was prepared from a pyrethrin I concentrate in the manner previously described.<sup>5</sup> After two recrystallizations from ethyl acetate and one from toluene it melted at 114–116°. The semicarbazone of pyrethrolone prepared from this material and recrystallized from ethyl acetate melted at 205° and decomposed with gas evolution at 206°.

The pyrethrolone obtained from this material by hydrolysis with potassium bisulfate solution had the following physical constants: it distilled at 130–135° at 0.35 mm.;  $n_D^{20}$  1.5324; in ether solution  $[\alpha]_D^{20}$  +14.85° ( $C = 11.7$ ).

**Pyrethrolone from Pyrethrin II Semicarbazone.**—The semicarbazone of pyrethrin II prepared from the corresponding concentrate melted at 163–164°. The semicarbazone of pyrethrolone obtained from this preparation melted at 210° and decomposed at 212°. It was hydrolyzed with potassium bisulfate solution and yielded pyrethrolone with the following physical constants: distilled at 130–135° at 0.35 mm.;  $n_D^{20}$  1.5332; in ether solution  $[\alpha]_D^{20}$  +17.7° ( $C = 15.1$ ).

**Condensation of Pyrethrolone and Monomethyl Ester of Chrysanthemum Dicarboxylic Acid Chloride.**—The acid chloride of chrysanthemum dicarboxylic acid monomethyl ester was prepared from pure chrysanthemum dicarboxylic acid monomethyl ester obtained by hydrogenation of pyrethrin II concentrate.<sup>6</sup> Two grams of the ester acid

(5) Haller and LaForge, *J. Org. Chem.*, 1, 38 (1936).

(6) Haller and LaForge, *ibid.*, 2, 49 (1937).

was treated with 3 g. of purified thionyl chloride in 20 cc. of dry petroleum ether at room temperature. After standing overnight the solvent and excess thionyl chloride were removed under reduced pressure and the residue was distilled at 0.2 mm. It boiled at 88–92°. The yield was 1.9 g.

The synthesis of pyrethrin II was carried out under the conditions employed by Staudinger and Ruzicka. In one experiment pyrethrolone originating from pyrethrin I semicarbazone was employed, in another pyrethrolone from pyrethrin II semicarbazone. In both experiments the proportions employed were pyrethrolone 0.55 g., acid chloride 0.9 g., dry benzene 5 cc., quinoline 1 cc. After two days at room temperature, water was added and the reaction products were extracted with ether. The solutions were washed with dilute acid, then with dilute sodium carbonate solution and dried. The residue (about 1 g.) from each experiment consisted of yellow oil.

When the oils from each experiment were treated with semicarbazide hydrochloride in pyridine–alcohol solution, and the procedure described for the isolation of pyrethrin II semicarbazone was followed, no crystalline products were obtained.

**Condensation of Tetrahydropyretrolone and Monomethyl Ester of Chrysanthemum Dicarboxylic Acid Chloride.**—Six-tenths of a gram of tetrahydropyretrolone obtained by hydrolysis of tetrahydropyretrolone semicarbazone, which was prepared by the hydrogenation of pyrethrolone semicarbazone derived from pyrethrin I semicarbazone, 1.1 g. of chrysanthemum dicarboxylic acid monomethyl ester acid chloride, and 1 cc. of quinoline in 5 cc. of dry benzene were allowed to stand for two days at room temperature. The solution was separated from the crystalline quinoline hydrochloride, which was washed with benzene. The combined solutions were washed successively with water, dilute acid, carbonate solution, and water, and then dried. The residue obtained after removal of the solvent, and which consisted of a light yellow oil, was treated with 0.5 g. of semicarbazide hydrochloride, 1 cc. of water, 1.8 cc. of pyridine, and 4.5 cc. of ethanol. After forty-eight hours the solution was concentrated under reduced pressure, then diluted with water and extracted with ether. The ether solution, after being washed with dilute acid, sodium carbonate solution, and water, was dried and concentrated to a sirup. The product crystallized on stirring with a small amount of a mixture of 2 parts of alcohol and 1 of water. It was filtered and washed with a little of the same solution. The dried crude product weighed 0.6 g. It was recrystallized by dissolving in 3 or 4 cc. of ethanol and adding a little water. The purified substance melted at 140°. A mixture with authentic tetrahydropyretrolone II semicarbazone also melted at 140°.

*Anal.* Calcd. for  $C_{23}H_{35}N_3O_8$ : C, 63.74; H, 8.08. Found: C, 63.87, 64.24; H, 8.01, 7.98.

**Condensation of Tetrahydropyretrolone and Chrysanthemum Monocarboxylic Acid Chloride.**—One and one-fourth grams of tetrahydropyretrolone from pyrethrin I semicarbazone, 1.7 g. of chrysanthemum monocarboxylic acid chloride, and 2 cc. of quinoline in 10 cc. of dry benzene were allowed to stand for two days. The solution was separated from the crystalline quinoline hydrochloride, which was washed with benzene. The benzene solution

was washed with dilute acid, sodium carbonate solution and water, and then dried. The solvent was removed under reduced pressure, leaving 2.5 g. of yellow oil. It was treated with 1.6 g. of semicarbazide hydrochloride in 3 cc. of water, 4 cc. of pyridine, and 10 cc. of ethanol. After two days the solvents were removed under reduced pressure, water was added, and the material was extracted with ether. A small amount of crystalline material melting at 196° (tetrahydropyretrolone semicarbazone) separated from the ether and was removed. The ether solution, after being washed with dilute acid, sodium carbonate solution, and water, was dried and the solvent removed. The resulting sirup crystallized on addition of petroleum ether; yield 0.6 g. The crude product was dissolved in ether and filtered from a small amount of the substance melting at 196°. The solution was concentrated to 15 cc. and an equal quantity of petroleum ether was added. On slow evaporation crystals were deposited, which were removed by filtration and washed with petroleum ether; yield 0.5 g. It melted at 55–60°.

*Anal.* Calcd. for  $C_{22}H_{35}N_3O_8$ : C, 67.86; H, 9.00. Found: C, 68.23, 68.47; H, 8.79, 9.08.

**Hydrogenation of Pyrethrin I Semicarbazone.**—Two grams of pyrethrin I semicarbazone, twice recrystallized from ethyl acetate, was dissolved in 20 cc. of ethyl acetate and shaken in an atmosphere of hydrogen with platinum oxide catalyst. After ten minutes 235 cc. of hydrogen, corresponding to four atoms, had been absorbed and the reaction had practically ceased. The solution was filtered, the solvent was removed under reduced pressure, and the residue was dissolved in ether. The ether solution was washed with cold 10% potassium carbonate solution and with water and then dried over sodium sulfate. The product remaining after removal of the ether was recrystallized from ether, and 0.45 g. of a substance (No. 989) which melted at 82–84° was obtained. On addition of petroleum ether to the mother liquor a second crop (0.85 g.) with a melting point of 82–84° (No. 990) was obtained. The ether–petroleum ether filtrate yielded a third crop (0.60 g.) (No. 992) having a melting point of 67–70°.

*Anal.* Calcd. for  $C_{22}H_{35}N_3O_8$ : C, 67.86; H, 9.00. Found: (No. 989) C, 68.46, 68.21; H, 9.15, 9.05; (No. 990); C, 68.46, 68.25; H, 9.08, 8.97; (No. 992) C, 67.74, 67.83; H, 8.66, 8.87.

### Summary

Pyrethrolone derived from purified pyrethrin I semicarbazone is identical with pyrethrolone prepared from pure pyrethrin II semicarbazone.

Condensation of the monomethyl ester of chrysanthemum dicarboxylic acid chloride and pyrethrolone gave a pyrethrin II that did not yield a crystalline semicarbazone.

Tetrahydropyretrolone and monomethyl ester chrysanthemum dicarboxylic acid chloride react to form tetrahydropyretrolone II, which yields a semicarbazone identical with the product obtained on catalytic hydrogenation of pyrethrin II semicarbazone.

Condensation of tetrahydropyretrolone and

chrysanthemum monocarboxylic acid chloride gave a tetrahydropyrethrin I which yielded a semicarbazone having a melting point slightly

lower than the products obtained on hydrogenation of purified pyrethrin I semicarbazone.

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## Alkanolamines. II. Reaction of the Chloronitrobenzenes with Monoethanolamine

BY CHESTER B. KREMER

In a previous communication<sup>1</sup> there was reported the condensation of triethanolamine with aniline to form phenylpiperazine-ethanol. This condensation involved the hydroxyl groups of the alkanolamine and subsequent splitting out of water molecules. In the present research, it is the amine hydrogen of the alkanolamine which is made to combine with a chlorine atom on the benzene nucleus, giving rise to anilino-ethanols. Compounds of this type are usually synthesized by treating aromatic amines with the appropriate chlorohydrin.

All attempts to condense chlorobenzene directly with an alkanolamine failed. The introduction of a nitro group into the ring, ortho or para to the chlorine atom, enables this reaction to proceed. The reaction proceeds more readily as the number of substituted groups on the benzene ring increases. Thus, 2,4-dinitrochlorobenzene reacts easily with monoethanolamine to form the substituted anilino-ethanol.<sup>2</sup> If the benzene ring be heavily loaded, it is even possible to effect the replacement of a nitro group, as seen in the condensation of 3,4,6-trinitrotoluene with monoethanolamine to give 2-(4,6-dinitro-*m*-toluino)-ethanol.<sup>3</sup>

This paper presents the results obtained in condensing the chloronitrobenzenes with monoethanolamine in the presence of anhydrous sodium carbonate. In all of these reactions, there was an accompanying reduction of the chloronitrobenzenes to the azo and/or aniline state. The reduction of organic compounds by mono-, di- and triethanolamines was first reported by Meltsner, *et al.*<sup>4</sup> In the present research, *m*-chloronitrobenzene was found not to condense, only reduction occurring. The other

two isomeric chloronitrobenzenes yielded solid condensation products in addition to the reduction products. Of these condensation compounds, 2-(*o*-nitroanilino)-ethanol has been reported previously.<sup>5</sup>

### Experimental

**Reaction with *o*-Chloronitrobenzene.**—One mole of the chloronitrobenzene was placed in a 3-necked round-bottomed flask with two moles of anhydrous sodium carbonate. The mixture was heated with a small flame until the chloronitrobenzene was melted completely. Then one mole of monoethanolamine was added slowly by means of a dropping funnel, mechanical stirring being employed and heating with a small flame continued. After addition of the ethanolamine had been completed, the mixture was refluxed for eight hours with continued stirring.

The mixture was then steam distilled, the steam distillate extracted with ether (ethyl), and the extract dried over sodium hydroxide. Upon removal of the ether and fractionation of the resulting residue, a light yellow oil boiling at 208° was obtained. By conversion to its hydrochloride, the liquid was further identified as *o*-chloroaniline; yield 5-8%.

The residue in the steam distillation flask consisted of two layers; a reddish water layer and a heavy black oil. The latter was run off by means of a separatory funnel and was found to solidify on cooling. Several recrystallizations of the black crystalline solid from chlorobenzene gave an orange-red product melting at 76°: calculated % N for 2-(*o*-nitroanilino)-ethanol, 15.38; N found, 15.46; yield, 60-70%.

**Reaction with *m*-Chloronitrobenzene.**—The relative amounts and procedure were the same as those given above for the ortho compound, and the ether extract of the steam distillate yielded, after removal of ether and fractionation of residue, a light orange liquid boiling at 229-231°. Conversion of this product into its hydrochloride completed its identification as *m*-chloroaniline; yield 50-60%.

A solid residue in the steam distillation flask was filtered off and recrystallized several times from ethyl alcohol. A light orange product melting at 101° was obtained. This corresponds to the azo compound. A mixed melting point with an authentic sample of 3,3'-dichloroazobenzene showed no depression; yield 30-40%.

**Reaction with *p*-Chloronitrobenzene.**—The relative amounts and procedure were the same as above, except

(1) C. B. Kremer, *THIS JOURNAL*, **58**, 379 (1936).

(2) LeRoy V. Clark, *J. Ind. Eng. Chem.*, **25**, 1385 (1933).

(3) Giovanni Racciu, *Atti. accad. sci. Torino Classe sci. fis. mat. nat.*, **69**, 364 (1934).

(4) M. Meltsner, C. Wohlberg and M. J. Kleiner, *THIS JOURNAL*, **57**, 2554 (1935).

(5) P. Karrer, E. Schlittler, K. Pfäehler and F. Benz, *Helv. Chim. Acta*, **17**, 1516-1523 (1934).