655. *The Rotatory Dispersion and Circular Dichroism of (—)-γ-Chloro-γ-nitroso-δ-phenylvaleric Acid.*

By Stotherd Mitchell and W. E. F. Naismith.

We have obtained (—)-*γ-chloro-γ-nitroso-δ-phenylvaleric acid* by fractional crystallisation of the (±)-compound combined with (+)-α-(2-hydroxy-1-naphthyl)benzylamine,

$OH{\cdot}C_{10}H_7{\cdot}CHPh{\cdot}NH_2$.

The resolved acid exhibits the Cotton effect in the region of absorption due to the nitroso-group. The specific rotation (in alcoholic solution) has a positive maximum of +372° at 5900 A., passes through zero at about 6500 A., and has a negative maximum of —400° at 6760 A. We have represented the circular dichroism curve as the sum of two probability curves, and have calculated partial rotations and anisotropy factors associated with each of these components.

In connection with work on asymmetric photochemical action, it became desirable to study the rotatory dispersion and circular dichroism of a chloronitroso-acid which had been resolved by one of the classical methods. Some progress in this direction has already been recorded. Mitchell and Simpson (*J.*, 1940, 784) prepared (—)-menthyl (+)-β-chloro-β-nitrosobutyrate, but were unable to isolate the corresponding acid. Mitchell, Schwarzwald, and Simpson (*J.*, 1941, 602) showed that γ-chloro-γ-nitrosovaleric acid was readily obtained and could be kept for several weeks without appreciable decomposition. This (±)-acid formed stable salts with (—)-menthylamine, but no resolution resulted when they were fractionally crystallised from *n*-hexane. A number of alkaloids were then tried in place of menthylamine, but in most cases only viscous oils resulted. The quinine salts were solid, however, and crystallisation from methyl acetate produced some resolution, the (−)-base–(−)-acid component being the less soluble. Noticeable decomposition of the salts occurred when they were left in contact with the solvent for only a few hours at 0°. Somewhat similar results were obtained with "(+)-β-naphthol-phenylaminomethane" [(+)-α-(2-hydroxy-1-naphthyl)benzylamine] $OH\cdot C_{10}H_7\cdot CHPh\cdot NH_2$, but in this case (with ethyl acetate as solvent) the (+)-base–(+)-acid component tended to separate first. A large number of crystallisations would have been required for complete resolution, so we decided to try an acid of higher molecular weight. We were thus led to prepare *γ-chloro-γ-nitroso-δ-phenylvaleric acid*, which turned out to be very suitable for our purpose.

The salts produced by combining the (±)-acid with (+)-α-(2-hydroxy-1-naphthyl)benzylamine were reasonably stable, and were submitted to fractional crystallisation from ethyl acetate. Table I shows the progress of the resolution, values of the observed rotation being given for two wave-lengths. The acid was recovered from the tenth fraction, and after crystallisation from *n*-hexane was used for the optical measurements.

TABLE I.

c = 2·008 g./100 c.c. (in methyl alcohol); l = 1 dm.; t = 18°.

Fraction	0	2	4	6	8	9	10
α_{5200},°	1·01	1·34	1·59	1·81	2·05	2·08	2·08
α_{5600},°	0·77	1·26	1·54	1·91	2·18	2·21	2·22

TABLE II.

Rotatory Dispersion in Alcohol.

Solutions: (*a*) c = 2·004; (*b*) c = 0·681 g./100 c.c.; t = 18°.

Solution (*a*); l = 1 dm.			Solution (*b*); l = 0·6 dm.			Solution (*b*); l = 0·25 dm.		
λ.	α.	[α].	λ.	α.	[α].	λ.	α.	[α].
5000	+3·85°	+192·2°	5400	+1·09°	+266·8	6200	+0·52°	+306·0°
5100	+4·11	+205·1	5500	+1·18	+288·8	6300	+0·48	+282·0
5200	+4·42	+220·6	5600	+1·27	+310·9	6400	+0·30	+176·3
5300	+4·80	+239·5	5700	+1·36	+332·9	6500	−0·07	− 41·1
			5800	+1·48	+362·0	6600	−0·47	−276·2
			5900	+1·52	+371·9	6700	−0·65	−381·9
			6000	+1·43	+349·9	6800	−0·67	−393·8
			6100	+1·32	+323·0	6900	−0·55	−323·2
						7000	−0·40	−235·1

TABLE III.

Circular Dichroism in Alcohol.

c = 0·681 g./100 c.c.; l = 2·5 cm.; t = 18°.

λ.	Ellipticity.	$\varepsilon_l - \varepsilon_r$.	λ.	Ellipticity.	$\varepsilon_l - \varepsilon_r$.	λ.	Ellipticity.	$\varepsilon_l - \varepsilon_r$
5400	−0·05°	−0·022	5900	−0·35°	−0·151	6600	−0·97°	−0·417
5500	−0·07	−0·030	6000	−0·49	−0·211	6700	−0·62	−0·267
5600	−0·11	−0·051	6100	−0·59	−0·254	6800	−0·38	−0·164
5700	−0·16	−0·069	6200	−0·69	−0·297	6900	−0·24	−0·103
5800	−0·25	−0·108	6300	−0·83	−0·357	7000	−0·13	−0·056
			6400	−1·02	−0·439			
			6500	−1·13	−0·486			

TABLE IV.

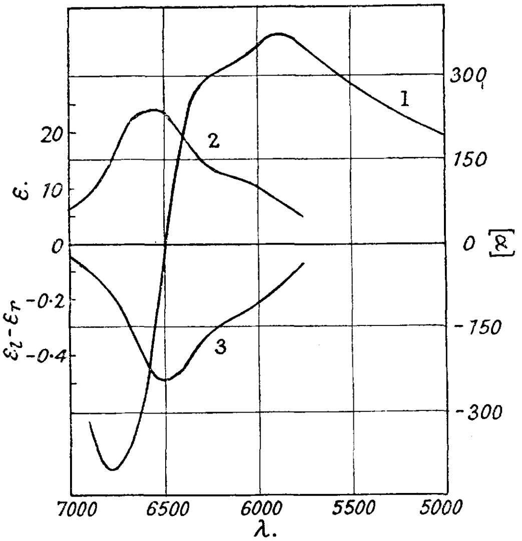
Absorption in Alcohol.

Concn., 0·07736M.; l = 1 cm.

λ_1.	λ_2.	ε.	λ_1.	λ_2.	ε.	λ_1.	λ_2.	ε.
7190	5480	2·59	6860	6020	10·34	6740	6370	18·09
7100	5660	3·88	6830	6140	11·63	6725	6400	19·39
7025	5770	5·17	6810	6230	12·93	6700	6430	20·68
6970	5830	6·41	6790	6270	14·22	6670	6460	21·98
6930	5890	7·76	6770	6310	15·52	6620	6500	23·27
6890	5950	9·05	6755	6345	16·81			

Readings of rotatory dispersion and circular dichroism were made visually with the apparatus previously described (cf. Mitchell and Simpson, *J.*, 1940, 784), and the results are set out in Tables II and III. The absorption data were recorded photographically with a Spekker photometer and a glass spectrograph using Ilford long-range plates. The wave-lengths λ_1 and λ_2, at which the double spectrograms had equal density, were found by means of a Hilger microphotometer, and are given in Table IV along with the corresponding molecular extinction coefficients, ε.

FIG. 1.



1. *Rotation.* 2. *Absorption.* 3. *Circular dichroism.*

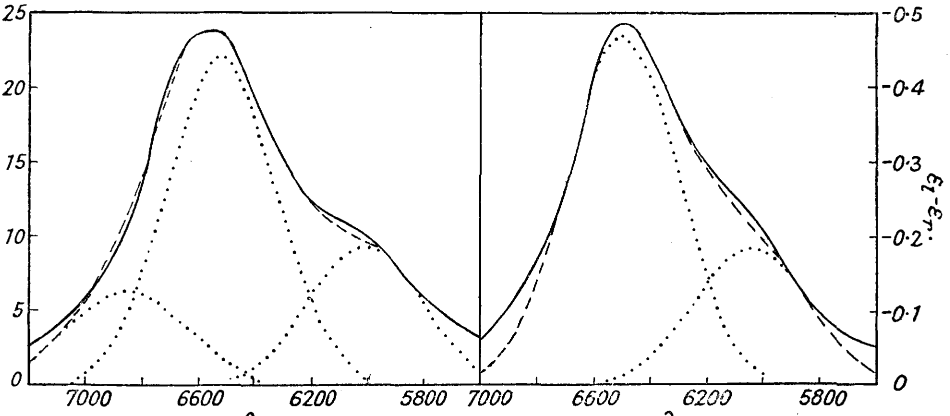
In Fig. 1 the curves of rotatory dispersion, absorption, and circular dichroism are all plotted on the same wave-length scale. A study of this diagram reveals three points of interest. (1) The absorption and circular dichroism curves are similar in shape, but the former is broader than the latter, and $\varepsilon_{\text{max.}}$ occurs at a slightly longer wave-length than $(\varepsilon_l - \varepsilon_r)_{\text{max.}}$. (2) The rotatory dispersion curve crosses the axis of zero rotation at the same wave-length ($\lambda = 6500$ A.) as $(\varepsilon_l - \varepsilon_r)_{\text{max.}}$. (3) The circular-dichroism curve is made up of two parts, and the form of the rotatory dispersion curve suggests that it may contain components related to each of these parts.

We proceeded therefore to analyse the (full line) circular-dichroismcurve, Fig. 2 (*b*), into two (dotted) curves of the type

$$(\varepsilon_l - \varepsilon_r) = (\varepsilon_l - \varepsilon_r)_{\text{max.}} e^{-[(\lambda - \lambda_0)/\theta]^2}$$

where λ_0 is the wave-length corresponding to $(\varepsilon_l - \varepsilon_r)_{\text{max.}}$ and θ is defined by $\lambda' = 1{\cdot}6651\theta$, λ′ being the half width of the band. The sum of these two component curves is shown as a broken line, which agrees quite well with the experimental curve.

FIG. 2.



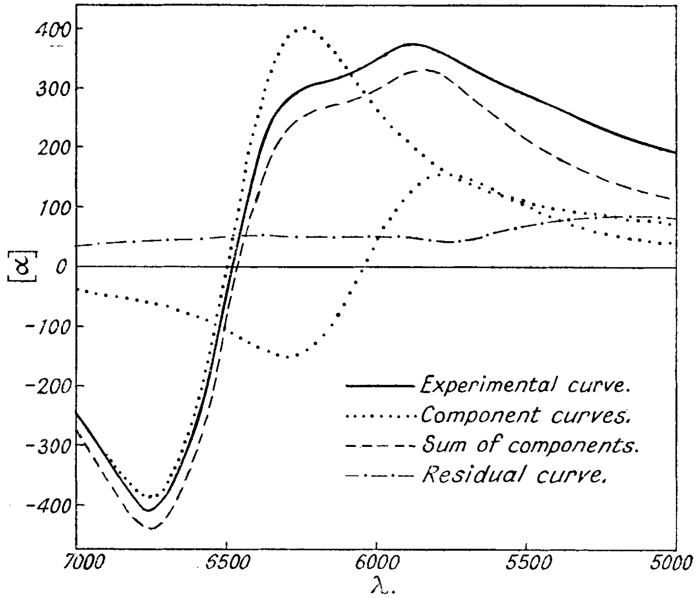
(*a*) *Absorption.* (*b*) *Circular dichroism.*

The contributions to the rotatory dispersion associated with each of these component circular-dichroism curves were then calculated by means of Kuhn's equation as modified by Lowry and Hudson (*Phil. Trans.*, 1933, *A*, **232**, 117) and are shown dotted in Fig. 3. When the sum of these dotted curves (broken line) is subtracted from the experimental curve (full line) the residual curve rises more or less uniformly towards the shorter wave-lengths, showing that the anomalies caused by the nitroso-group have been fairly well eliminated.

In order to calculate the anisotropy factors (*g*) we have represented the absorption curve, Fig. 2(*a*), as the sum of three components, two of which correspond to those of the circular-dichroism curve. For the large component $g = (\varepsilon_l - \varepsilon_r)_{\text{max.}}/\varepsilon_{\text{max.}} = -0{\cdot}023$, and for the small (short-wave) component $g = -0{\cdot}020$.

The presence of the third (long-wave) component is not very clearly indicated by the form of the absorption curve in this case, but it is quite apparent with some other nitroso-compounds, *e.g.*, nitrosyl chloride (*Proc. Roy. Soc.*, 1939, *A*, **172**, 432).

FIG. 3.



EXPERIMENTAL.

Preparation of δ-Phenyl-lævulic Acid, $CH_2Ph\cdot CO\cdot CH_2\cdot CH_2\cdot CO_2H$.—The half ester $CHPh{:}C(CH_2Ph)\cdot CH(CO_2Et)\cdot CH_2\cdot CO_2H$ was obtained by boiling dibenzyl ketone and diethyl succinate under reflux for 6 hours with potassium *tert.*-butoxide in an excess of *tert.*-butyl alcohol (cf. Johnson, Goldman, and Schneider, *J. Amer. Chem. Soc.*, 1945, **67**, 1357). Hydrolysis of the half ester with 5% sodium hydroxide solution produced the corresponding dicarboxylic acid which was then oxidised with 4% potassium permanganate solution at 0° (cf. Russwurm and Schultz, *Annalen*, 1899, **308**, 175) to give (impure) δ-phenyl-lævulic acid. The latter was purified through the semicarbazone. After liberation with dilute sulphuric acid, the keto-acid was crystallised from light petroleum and had m. p. 54—55°. Treatment with hydroxylamine hydrochloride and potassium acetate gave the oxime, m. p. 98°.

γ-Chloro-γ-nitroso-δ-phenylvaleric Acid, $CH_2Ph\cdot CCl(NO)\cdot CH_2\cdot CH_2\cdot CO_2H$.—The thoroughly dried oxime of δ-phenyl-lævulic acid was dissolved in dry ether, and chlorine was passed into the solution until a green colour appeared. Removal of the ether under reduced pressure gave a stable blue solid. After crystallisation from *n*-hexane, this *acid* had m. p. 74° (Found : C, 73·2; H, 8·8; N, 4·2. $C_{11}H_{12}O_3NCl$ requires C, 73·1; H, 9·0; N, 4·1%).

Resolution of (±)-*γ-Chloro-γ-nitroso-δ-phenylvaleric Acid.*—We prepared first (±)-α-(2-hydroxy-1-naphthyl)benzylamine [" (±)-β-naphthol-phenylaminomethane," *Org. Synth.*, 1929, **9**, 60] and then resolved it as described by Betti [*Gazzetta*, 1906, **36**, (2), 392].

On mixing of equimolecular quantities of the (+)-base and the (±)-chloronitroso-acid (in ether) a pale blue precipitate [(±)-acid–(+)-base] was obtained, having m. p. 102—105° (decomp.) (Found : C, 68·8; H, 5·4; N, 5·7. $C_{28}H_{27}O_4N_2Cl$ requires C, 68·5; H, 5·5; N, 5·7%). Addition of 66 g. of acid to 68·5 g. of base gave 110 g. of product which was submitted to fractional crystallisation from ethyl acetate, about 70% of material being recovered at each stage. The rotations of some of the fractions are given in Table I. After the tenth crystallisation, the remaining salt [(−)-acid–(+)-base] was treated with dilute hydrochloric acid, and the liberated (−)-acid was extracted with ether, dried, recovered, and finally crystallised from *n*-hexane (m. p. 78°).

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