cis-acid, identified by melting point and mixture melting point.

The sodium salt of the *trans*-**acid** (0.05 mole) also rapidly consumed bromine and evaporation of the carbonate-washed ether extract left 6.4 g. of yellowish crystals, m.p. 22–25°. White crystals (1.8 g., 20%) of **tolan**, m.p. 59–60°, were obtained by crystallization of the crude product from alcohol. Evaporation of the mother liquor and recrystallization from ether gave 4 g. (30%) of *trans*-α-bromostilbene, m.p. 30–31° (lit.[14] 31°). The carbonate wash yielded 2.3 g. (21%) of original *trans*-acid, m.p. 137–138°.

Sodium *trans*-cinnamate (0.2 mole) rapidly consumed 32 g. of bromine at 50°, with effervescence of carbon dioxide. Fractional distillation of the carbonate-washed ether extract gave 10 g. (27%) of ***trans*-β-bromostyrene**, b.p. 71–74° (1.3 mm.), m.p. 5–6°, $n^{20}D$ 1.6084 (lit.[15] m.p. 7°, $n^{20.5}D$ 1.6094), and 9.1 g. (13%) of β-bromostyrene dibromide, b.p. 110–113° (1.5 mm.), m.p. 35–36°, after recrystallization from 30–60° petroleum ether. The carbonate wash yielded 7.6 g. (26%) of *trans*-cinnamic acid. The infrared spectrum of the β-bromostyrene showed no *cis* bands.

***cis*-Cinnamic acid**, m.p. 64–66°,[16] was prepared by hydrogenation of phenylpropiolic acid over palladium-on-charcoal. **The sodium salt** (0.08 mole) gave 4.8 g. (32%) of **β-bromostyrene**, b.p. 58.5° (0.8 mm.), $n^{22}D$ 1.6060, and 7.4 g. (26%) of **β-bromostyrene dibromide**, m.p. 35–36°. The carbonate wash yielded 2.1 g. (17%) of ***cis*-cinnamic acid**, m.p. 55–56°.[16] A mixture of 60% *trans*- and 40% *cis*-β-bromostyrene, $n^{22}D$ 1.6055, had an infrared spectrum essentially identical to the sample from this bromination.

(15) C. Dufraisse, *Ann. chim.*, [9] **17**, 161 (1922).

(16) *cis*-Cinnamic acid is reported in different forms melting at 68°, 59° and 42°.

dl-Hydratropic acid[17] (0.1 mole), as its sodium salt in 150 ml. of water and 50 ml. of chloroform at 50°, consumed bromine rapidly at first and then quite slowly. The combined ether–chloroform extract was washed with aqueous carbonate, bisulfite and water. The carbonate yielded 10 g. (67%) of the original acid. The extract on distillation gave 1.2 g. (10%) of **acetophenone**, b.p. 38–40° (0.5 mm.) (confirmed by semi-carbazone), 1.4 g. (7.6%) of **α-phenethyl bromide**, b.p. 49–50° (0.6 mm.) (confirmed by infrared spectrum and copious precipitate with aqueous silver nitrate) and 1.0 g. (8.2%) of **α-phenethyl alcohol**, b.p. 65–67° (0.5 mm.).

d-Hydratropic acid, $\alpha^{24.8}D$ +47.5° (1 dm., neat, 60% opt. purity[18]), was similarly treated. From 0.1 mole, 9.7 g. (65%) of original acid was recovered, $\alpha^{25}D$ +46.1°, as well as 1.5 g. (8.5%) of **α-phenethyl bromide**, b.p. 47–48° (0.5 mm.), $\alpha^{25}D$ 0.00°. A second experiment also gave optically inactive bromide.

A 5-g. sample of active α-phenethyl bromide, prepared from active alcohol kindly supplied by Fabian T. Fang, was dissolved in 15 ml. of chloroform ($\alpha^{26.2}D$ +3.30°, 1 dm.) and heated at 50° for 20 minutes, $\alpha^{26.3}D$ +3.25°. When this procedure was repeated, but with a few drops of bromine added, the rotation fell to 0.00°. When five drops of bromine was added at room temperature, the observed rotation fell to +1.75° in 90 minutes and to zero after another two days in the cold (5°).

(17) E. L. Eliel and J. P. Freeman, THIS JOURNAL, **74**, 923 (1952).

(18) A. F. Fredga, *Arkiv. for Kemi*, **7**, 241 (1954).

PHILADELPHIA 4, PA.

[CONTRIBUTION FROM THE NOYES CHEMICAL LABORATORY, UNIVERSITY OF ILLINOIS, AND THE KEDZIE CHEMICAL LABORATORY, MICHIGAN STATE UNIVERSITY]

Electric Moments and Transannular Nitrogen–Carbonyl Interaction in Cyclic Aminoketones[1]

BY NELSON J. LEONARD, DUANE F. MORROW[2,3] AND MAX T. ROGERS

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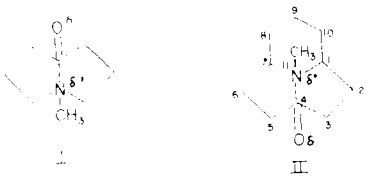
The dipole moments of 1-methylpiperidine, 1-ethyl-4-piperidone, pseudopelletierine and 11-methyl-11-azabicyclo[5.3.1]-hendecan-4-one (II) have been determined. The dipole moment of pseudopelletierine provides evidence for the preferred conformations of this compound. The moment of II indicates partial charge separation in the normal state of the molecule and provides compelling physical evidence of nitrogen–carbonyl interaction in this model bicyclic aminoketone.

There is considerable physical and chemical evidence for the occurrence of transannular nitrogen–carbonyl interaction[4] in cyclic aminoketones and aminoacyloins of medium ring size which have the carbonyl group placed diametrically across the ring from the tertiary amine grouping. 1-Methyl-1-azacycloöctan-5-one (I) is one representative of this class of compounds in which the N-C_{5} interaction represents a base–acid, nucleophilic–electrophilic, combination with a favorable entropy term. While the charge-separated form, $-\overset{|}{\overset{+}{N}}-\overset{|}{\underset{|}{C}}-O^{-}$, corresponds to the extreme of the possible electron redistribution, the properties (solubility, infrared and ultraviolet absorption, melting and boiling points) of 1-methyl-1-azacycloöctan-5-one are more in keeping with a representation (I) of partial charge separation. If this concept is correct, an aminoketone in which transannular N–C_{5} interaction can occur should exhibit a higher than normal electric moment, consistent with the greater charge separation. Accordingly, we have selected for synthesis and dipole moment study an aminoketone in which transannular interaction should be highly favored—11-methyl-11-azabicyclo[5.3.1]-hendecan-4-one (II).



I II

The synthesis of 11-methyl-11-azabicyclo[5.3.1]-hendecan-4-one (II) was accomplished by a reaction sequence starting with pyridine-2,6-dicarboxaldehyde (III). A Knoevenagel condensation of this dialdehyde with malonic acid in pyridine con-

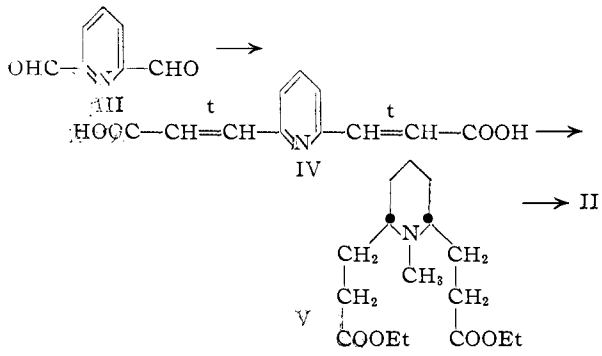
(1) Part IX in the series on Cyclic Aminoacyloins and Aminoketones; for Part VIII, see N. J. Leonard and M. Öki, THIS JOURNAL, **77**, 6245 (1955).

(2) National Science Foundation Fellow, University of Illinois, 1954–1956.

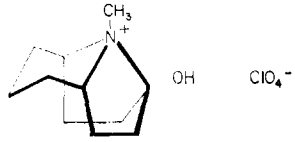
(3) Eli Lilly and Co. Fellow, University of Illinois, 1956–1957.

(4) N. J. Leonard, *Rec. Chem. Prog.*, **17**, 243 (1956).

taining piperidine resulted in pyridine-2,6-diacrylic acid (IV), which was converted by catalytic hydrogenation, methylation and esterification to diethyl 1-methylpiperidine-2,6-dipropionate (V). The yield to this stage was 73%. The Dieckmann ring closure of the aminodiester V was effected with

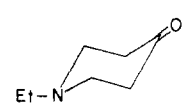


potassium *t*-butoxide in xylene using high speed stirring and high dilution,[5] and was followed by hydrolysis and decarboxylation. The aminoketone II, which was obtained in 23% yield, has an infrared carbonyl maximum at the lowest frequency we have observed for any aminoketone: 1664 cm.$^{-1}$ for a 10% solution in carbon tetrachloride. Moreover, a solution of 1.24×10^{-2} *M* concentration in the same solvent exhibited a *single* maximum, at 1657 cm.$^{-1}$, in the 6 μ region of a highly resolved spectrum,[6] indicating that 11-methyl-11-azabicyclo-[5.3.1]hendecan-4-one exists mainly in the interacted form (II). The ultraviolet absorption spectrum was similar to those of other cyclic aminoketones exhibiting transannular N–C_{CO} *interaction*.[7] Finally, transannular *reaction* of the tert.-amine and carbonyl groups, with development of a full bond between nitrogen and carbon, occurred with the aid of a protonic acid. The perchlorate salt of 11-methyl-11-azabicyclo[5.3.1]hendecan-4-one exists in transannular bonded form VI, as indicated by the strong infrared absorption maximum (mull) at 3365 cm.$^{-1}$ and transparency in the carbonyl region.



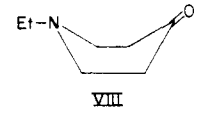
VI

The dipole moment of the model aminoketone II was determined in benzene solution. Measurements have also been made on 1-ethyl-4-piperidone and pseudopelletierine, in which the conditions for transannular interaction are unfavorable, and on 1-methylpiperidine for reference purposes. From the moments of cyclohexanone (3.07)[8] and 1-methylpiperidine (0.80) in benzene solution the moment computed for 1-ethyl-4-piperidone (chair form, VII) is 2.7 D. This value is in fair agreement with the observed value, 2.95 D., in view of the fact that tetrahedral angles were assumed at saturated carbon *and* nitrogen in making the calculation.[9] An explanation for the higher observed value may also be found in a partial contribution of



VII

$\mu_{calcd.}$ 2.7

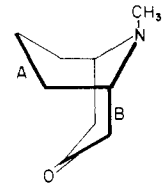


VIII

$\mu_{calcd.}$ 3.85

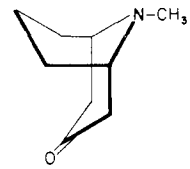
the less-favored boat conformation (VIII) of 1-ethyl-4-piperidone to the molecule in solution, as suggested for cyclohexane-1,4-dione[10] and 5β-androstane-3,17-dione.[11]

The moments expected for various conformations of pseudopelletierine are shown in IX, X, XI and XII. There is no reason for favoring the boat–



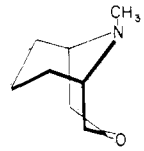
IX

$\mu_{calcd.}$ 2.7



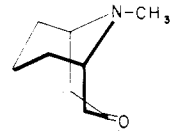
X

$\mu_{calcd.}$ 2.7



XI

$\mu_{calcd.}$ 3.85



XII

$\mu_{calcd.}$ 2.7

chair conformations of IX and X over the corresponding chair–chair conformations[12,13] except that scale molecular models suggest less steric repulsion in the boat–chair conformations as pictured (IX, X). The calculated dipole moments are of course unchanged when the A ring is converted to the chair conformation (B remaining in chair). Conformation XI may be excluded from consideration since the observed moment (2.75) is so much lower than the calculated value (*ca.* 3.85), and conformation XII, while it has a favorable calculated moment, exhibits greater steric opposition in the model than does X. The best inference from dipole moment and model studies is that conformations of pseudopelletierine related to IX and X are favored.[14] Infrared spectral data indicate that

(5) N. J. Leonard and R. C. Sentz, THIS JOURNAL, **74**, 1704 (1952).

(6) N. J. Leonard, M. Öki, J. Brader and H. Boaz, *ibid.*, **77**, 6237 (1955).

(7) N. J. Leonard and M. Öki, *ibid.*, **77**, 6239 (1955).

(8) M. T. Rogers, unpublished results.

(9) Other calculated moments in this paper were arrived at on the basis of similar assumptions.

(10) C. G. LeFèvre and R. J. W. LeFèvre, *J. Chem. Soc.*, 1696 (1935).

(11) H. R. Nace and R. B. Turner, THIS JOURNAL, **75**, 4063 (1953).

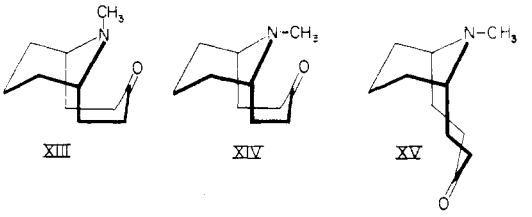
(12) K. Alder and H. A. Dortmann, *Chem. Ber.*, **86**, 1544 (1953).

(13) G. Fodor, *Bull. soc. chim. France*, 1032 (1956).

(14) For conclusions with respect to the conformation of the B ring (six-membered ring) in the related tropane series, see J. W. Visser, J. Manassen and J. L. deVries, *Acta Cryst.*, **7**, 288 (1954); B. L. Zentiz, C. M. Martini, M. Priznar and F. C. Nachod, THIS JOURNAL, **74**, 5564 (1952); A. K. Bose and D. K. R. Chaudhuri, *Nature*, **171**, 652 (1953); A. Nickon and L. F. Fieser, THIS JOURNAL, **74**, 5566 (1952); E. Hardegger and H. Ott, *Helv. Chim. Acta*, **36**, 1186 (1953); M. B. Sparke, *Chemistry & Industry*, 749 (1953); R. C. Cookson, *ibid.*, 337 (1953); ref. 13 and earlier articles by G. Fodor.

no appreciable transannular N–C_{co} interaction occurs in this molecule.

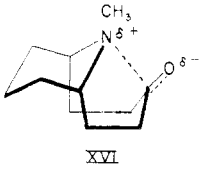
The maximum moment theoretically possible for 11-methyl-11-azabicyclo[5.3.1]hendecan-4-one on a linear additivity basis would be the sum (3.87) of the moments for 1-methylpiperidine and cyclohexanone. Actually, the calculated moments for the possible conformations XIII, XIV and XV fall short of this figure. Conformation XV may be



XIII XIV XV

$\mu_{calcd.}$ 3.6 $\mu_{calcd.}$ 3.6 $\mu_{calcd.}$ 2.3

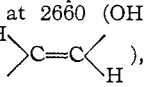
disregarded since the detailed infrared study of 11-methyl-11-azabicyclo[5.3.1]hendecan-4-one indicates no appreciable carbonyl absorption due to a non-interacted conformation. *The dipole moment observed for this aminoketone was 4.87D., or 1.27D. higher than the moment calculated for the favored conformations.* This increment of the observed over the calculated moment can be attributed to an additional charge separation in the normal state of the molecule (XVI) and provides



XVI

compelling physical evidence of nitrogen–carbonyl interaction in this model aminoketone. Since full charge separation would give the compound a dipole moment of 11–12 D.,[15] the partial charge separation can be estimated roughly at 11–12%.

Experimental[16]

Pyridine-2,6-diacrylic Acid.—A mixture of 100 g. (0.74 mole) of pyridine-2,6-dicarboxaldehyde (Aldrich Chemical Co.), 315 g. (3.02 moles) of malonic acid, 600 ml. of anhydrous pyridine and 10 ml. of piperidine was warmed on a steam-bath for 2 hr. and then heated under reflux for 4 hr. The mixture was cooled in ice and filtered. The solid was washed thoroughly with ethanol and ether. A second crop of crystalline material was collected, washed and added to the first crop. The product, after drying in a vacuum desiccator over calcium chloride, weighed 126 g. (78%). It crystallized from 66% aqueous dimethylformamide as colorless elongated prisms which decomposed rapidly above 315°. The infrared spectrum in Nujol mull exhibited maxima (selected) at 2660 (OH), 1674 (C=O), 1632 (C=C), 985 (*trans*- ), and 811 cm.$^{-1}$ (3 adjacent arom. H's).

Anal. Calcd. for $C_{11}H_9NO_4$: C, 60.27; H, 4.14; N, 6.39. Found: C, 60.08; H, 4.31; N, 6.51.

Diethyl 1-Methylpiperidine-2,6-dipropionate.—A slurry of 50 g. (0.23 mole) of pyridine-2,6-diacrylic acid in 640 ml. of glacial acetic acid was hydrogenated at 4 atm. at 60° with platinum oxide. After 5 mole equivalents of hydrogen had been absorbed and the uptake had ceased, the catalyst was removed by filtration and the filtrate was concentrated in vacuum. The viscous residue, with 90 ml. of 88% formic acid, was cooled in an ice-bath, and 20 g. (0.24 mole) of 36% formalin solution was added. The solution was allowed to warm to 25° over a period of 1 hr. and was then heated on a steam-bath for 20 hr. Additional formalin solution (6.7 g., 0.08 mole) was added after the first 5 hr. At the end of the heating period, 40 ml. of 12 *N* hydrochloric acid was added, and the solvents were removed. The dry residue was covered with a mixture of 150 ml. of absolute ethanol and 150 ml. of dry benzene, together with 0.3 g. of *p*-toluenesulfonic acid. The resulting solution was heated at reflux under an ethyl ester column until water separation ceased (72 hr.). Most of the solvent was removed at water-pump pressure on a steam-bath. The residue was cooled in ice, covered with 100 ml. of ether, and made strongly basic by addition of cold concentrated aqueous sodium hydroxide. The upper layer was separated and combined with five 100-ml. ether extracts of the aqueous layer. The ethereal solution was dried and concentrated, and the product was distilled at 115–120° (0.1 mm.), $n^{23}D$ 1.4651, yield 63 g. (93%).

Anal. Calcd. for $C_{16}H_{29}NO_4$: C, 64.18; H, 9.76; N, 4.68. Found: C, 64.38; H, 9.48; N, 4.68.

In a separate run, this series of reactions was interrupted at each stage, and the intermediate compounds were isolated. A portion of the hydrogenation product was treated with hydrochloric acid and then concentrated. The residual **piperidine-2,6-dipropionic acid hydrochloride** crystallized from glacial acetic acid as colorless prisms, m.p. 207–208°.

Anal. Calcd. for $C_{11}H_{20}ClNO_4$: C, 49.72; H, 7.59; N, 5.27. Found: C, 49.59; H, 7.72; N, 5.36.

The hydrochloride of **1-methylpiperidine-2,6-propionic acid** was isolated following the methylation stage and was recrystallized from ethanol–ethyl acetate as small colorless plates, m.p. 228.5–229.5°.

Anal. Calcd. for $C_{12}H_{22}ClNO_4$: C, 51.52; H, 7.93; N, 5.01. Found: C, 51.67; H, 7.82; N, 4.71.

11-Methyl-11-azabicyclo[5.3.1]hendecan-4-one (II).—The procedure was similar to that which had been used previously to effect Dieckmann closure of eight-membered ring aminoketones.[5] Using a high speed stirrer and a high dilution apparatus, a solution of 48.0 g. (0.16 mole) of diethyl 1-methylpiperidine-2,6-dipropionate in 800 ml. of anhydrous xylene was added over 104 hr. to a slurry of potassium *t*-butoxide prepared from 13.7 g. (0.35 g.-atom) of potassium and an excess of *t*-butyl alcohol in 1400 ml. of xylene. When addition of the diester was complete, the dark orange mixture was heated and stirred an additional 7 hr., cooled in ice, and extracted with six 100-ml. portions of 12 *N* hydrochloric acid and three 100-ml. portions of 6 *N* acid. To the combined acidic extracts was added 400 ml. of 12 *N* hydrochloric acid, and the mixture was heated under reflux for 24 hr. Concentration to a volume of 250 ml. was followed by cooling in ice and rendering strongly basic with cold concentrated aqueous sodium hydroxide solution. The mixture was extracted with eight 100-ml. portions of chloroform, the extracts were dried and concentrated, and the residue was sublimed at 80° (0.1 mm.) as colorless crystals, m.p. 137–142°, yield 6.65 g. (23%).

Anal. Calcd. for $C_{11}H_{19}NO$: C, 72.88; H, 10.56; N, 7.73. Found: C, 73.03; H, 10.26; N, 8.01.

The infrared spectrum of the aminoketone as a 10% solution in carbon tetrachloride exhibited a strong peak at 1664 cm.$^{-1}$. A solution of 1.24×10^{-2} *M* concentration exhibited a *single* peak (at 1675 cm.$^{-1}$) in the 6 μ region of a highly resolved spectrum. The ultraviolet absorption spectrum of the aminoketone in anhydrous ether had a single maximum at 221 mμ, log ϵ 3.78.

The perchlorate salt was prepared in ether and recrystallized from absolute ethanol as colorless prisms, which decomposed rapidly above 330° and had a strong infrared maximum (mull) at 3365 cm.$^{-1}$, but was transparent in the 6 μ region.

Anal. Calcd. for $C_{11}H_{20}ClNO_5$: C, 46.89; H, 7.16; N, 4.97. Found: C, 47.06; H, 7.39; N, 4.75.

The picrate, prepared in absolute ethanol, was recrystallized from 2:1 water–ethanol as short yellow needles, which decomposed rapidly above 312°.

(15) There is some uncertainty as to the values which should be assumed for the N^+–C and C–O^- bond distances.

(16) The authors are indebted to Miss Claire Higham and Mr. Jozsef Nemeth for the microanalyses and to Mr. James Brader for determination of the infrared spectra.

TABLE I

EMPIRICAL CONSTANTS, MOLAR REFRACTIONS, MOLAR POLARIZATIONS AND ELECTRIC MOMENTS IN BENZENE SOLUTION AT 25°

Compound	ϵ_1	a	v_1	b	P_2	MR_D	$\mu_{obsd.}$
11-Methyl-11-azabicyclo[5.3.1]hendecan-4-one	2.2730	33.17	1.14478	−0.496	537.6	52.79	4.87
Pseudopelletierine	2.2725	10.65	1.14478	− .443	198.5	43.49	2.75
1-Ethyl-4-piperidone	2.2725	11.90	1.14476	− .158	214.6	36.26	2.95
1-Methylpiperidine	2.2725	0.555	1.14480	− .117	44.68	31.65	0.80

Anal. Calcd. for $C_{17}H_{22}N_4O_8$: C, 49.75; H, 5.41; N, 13.65. Found: C, 49.42; H, 5.38; N, 13.34.

The infrared spectrum of the picrate (mull) exhibited strong maxima at 3225, 3100 and 1637 cm.$^{-1}$ and was transparent in the region 2000–1640 cm.$^{-1}$. The spectrum was similar to that of 1-methyl-1-azacyclodecan-6-one picrate.[17]

Pseudopelletierine.—The ultraviolet spectrum of pseudopelletierine[18] in absolute ether exhibited maxima at 213 mμ, log ε 2.99, and 246 mμ, log ε 2.93. The infrared spectrum of a 5% solution in carbon tetrachloride exhibited a strong sharp maximum at 1709 cm.$^{-1}$.

The perchlorate salt was formed in ether and recrystallized from absolute ethanol as colorless needles, m.p. 256–258°, infrared maxima (Nujol mull) at 3070, 1728 and 1710 cm.$^{-1}$, the latter the more intense of the carbonyl pair.

Anal. Calcd. for $C_9H_{16}ClNO_5$: C, 42.62; H, 6.36; N, 5.52. Found: C, 42.61; H, 6.63; N, 5.33.

The *p*-toluenesulfonate salt was made in order to determine whether the double carbonyl peak for the perchlorate would be found in salts with other anions or whether this infrared anomaly might not be a property of the crystal. The *p*-toluenesulfonate was formed in ether and recrystallized from absolute ethanol as colorless plates, m.p. 171–172°. The salt exhibited infrared maxima at 2680, 2560 $(\overset{+}{N}\text{-H})$ and 1733 cm.$^{-1}$ (C=O) in Nujol mull, and at 3440, 2480 $(\overset{+}{N}\text{-H})$ and 1729 cm.$^{-1}$ (C=O) in chloroform (5% solution).

Anal. Calcd. for $C_{16}H_{23}NO_4S$: C, 59.05; H, 7.12; N, 4.30. Found: C, 59.46; H, 7.16; N, 4.29.

Other Materials.—1-Ethyl-4-piperidone[19] and 1-methylpiperidine[20] were prepared in the usual way and purified by fractional distillation. Benzene was purified by fractional crystallization and was dried over sodium.[21]

Apparatus and Method.—The dielectric constants and densities of five solutions, ranging in concentration from 0.0007 to 0.007 in mole fraction solute, were measured in benzene solution at 25°. The apparatus, technique, method of calculation and definition of symbols have been given elsewhere.[21] The constants ϵ_1, a, v_1, b of the Halverstadt–Kumler equation are shown in Table I for each compound along with the derived value of the molar polarization of solute at infinite dilution, P_2. The sum of the electronic and atomic polarizations was taken to be equal to the molecular refraction MR_D calculated from empirical constants. The observed values of the electric moments are shown in Table I; the probable error in each is about ±0.1D.

(17) N. J. Leonard, M. Öki and S. Chiavarelli, THIS JOURNAL, **77**, 6234 (1955).

(18) A. C. Cope, H. L. Dryden, Jr., C. G. Overberger and A. A. D'Addieco, *ibid.*, **73**, 3416 (1951).

(19) S. M. McElvain, *ibid.*, **46**, 1721 (1924).

(20) J. von Braun, *Ber.*, **37**, 2915 (1904).

(21) M. T. Rogers, THIS JOURNAL, **77**, 3681 (1955).

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The Chemistry and Synthetic Applications of the Phenanthridinone System

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In a study of the substitutional chemistry of phenanthridinone it was found that this system could be chlorinated, iodinated and sulfonated readily at the 2-position. A nitro group could be introduced easily into the 4-position only if the 2-position was blocked. However, nitration and bromination of 2-acetaminophenanthridinone may have led to the 1- or 3-substituted derivatives. In addition, the N-methylation of certain electronegatively substituted phenanthridinones was accomplished by heating their potassium salts with methyl iodide in ethanol. The reduced reactivity of the carbonyl group of phenanthridinone was shown in its slow reaction with butyllithium and also by the halogen–metal interconversion reaction possible between the 2-bromo isomer and butyllithium. Although phenanthridine could be hydroxylated by potassium hydroxide to give phenanthridinone, infrared data did not support the representation of this compound as 6-hydroxyphenanthridine.

Although phenanthridine (9-azaphenanthrene) was isolated as early as 1884,[1] the system received little attention until some 50 years later, when 6-arylphenanthridines were shown to be efficacious in fighting bovine trypanosomiasis.[2] Consequently, in recent years a multitude of phenanthridine derivatives have been prepared by the cyclization of 2-acylaminobiphenyls, in order to develop superior trypanocides and to evaluate the general biological activity of this heterocyclic system.[3] Generally, the ring closure of 2-acylaminobiphenyls is successful, but oftentimes the suitably substituted 2-aminobiphenyl is cumbersome to synthesize.

The recently developed cyclization of 2-biphenylyl isocyanate[4] to phenanthridinone (I) affords an excellent preparative method for this amide. Accordingly, the attractive alternative of introduc-

(1) C. Graebe, *Ber.*, **17**, 1370 (1884).

(2) G. T. Morgan and L. P. Walls, *J. Chem. Soc.*, 389 (1938).

(3) (a) L. P. Walls, *ibid.*, 294 (1945); 1031 (1946); 67 (1947); 3511 (1950); (b) R. S. Theobald and K. Schofield, *Chem. Revs.*, **46**, 171 (1950).

(4) J. M. Butler, THIS JOURNAL, **71**, 2578 (1949).