Proton Magnetic Resonance Spectra, Stereochemistry, and Synthesis of 2-Arylnitrocyclohexanes and 2-Arylcyclohexylamines[1]

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The stereochemistry of the six isomeric *cis*- and *trans*-2-(chlorophenyl)nitrocyclohexanes; the four isomeric *ortho*- and *para-cis*- and *trans*-2-tolylnitrocyclohexanes; the six isomeric *cis*- and *trans*-2-(chlorophenyl)cyclohexylamines; and the four isomeric *ortho*- and *para-cis*- and *trans*-2-tolylcyclohexylamines has been investigated by n.m.r. The n.m.r. spectra of all isomers are consistent with structures in which the cyclohexane ring is in a chair conformation with the aromatic group in equatorial orientation. The signals of the hydrogen atoms on C-2 have a larger paramagnetic shift in the *ortho*-substituted compounds than in the corresponding *meta* and *para* isomers. This is explained in terms of long range shielding effects of the benzene ring. The observed coupling constants between axial hydrogens on adjacent carbon atoms are consistent with those previously observed for 2-arylcyclohexanols but are generally larger than values reported in standard textbooks.

The usefulness of n.m.r. in configurational and conformational analysis of six-membered ring compounds has been well demonstrated.[3-8] Of particular importance for such investigation is the fact that the spin-spin coupling constant between axial hydrogens on adjacent carbon atoms is larger (observed J_{aa} of about 8–11.5 c.p.s.) than between hydrogens in other orientations on adjacent carbon atoms (observed J_{ee} and J_{ae} of about 2–4.5 c.p.s.).[3-8] In this investigation the observed J_{aa} values are quite constant, 11.5 ± 0.5. These values are consistent with values previously observed for 2-arylcyclohexanols[6,7] but are generally higher than values reported on page 193 of ref. 3.

The conformations and n.m.r. spectra of *trans*- and *cis*-2-(*p*-chlorophenyl)nitrocyclohexane and the two corresponding cyclohexylamines are shown in Fig. 1. The signals of the aromatic hydrogens are not shown. Fig. 2 gives the pertinent parts of the spectra of the remaining compounds. In all cases the spectra are consistent with structures in which the cyclohexane ring is in a chair conformation with the aromatic group in equatorial orientation. In no case do the spectra give any evidence of the presence of two conformers at room temperature in the solvents used for measurements. Unequivocal assignment of configurations and conformations is possible from the n.m.r. signals of the hydrogen atoms on C-1 and C-2, which are isolated from the signals of the other ring hydrogens. The assignment is especially clear cut in the case of the nitro compounds where there is no overlapping of the two signals because of the larger paramagnetic shift of the 1-hydrogen.

The nitro compounds giving a sextuplet for the signal of the hydrogen on C-1 (τ of 5.19 to 5.47) are readily characterized as the *trans* isomers in a chair conformation with both substituents equatorial. The sextuplet arises from an axial hydrogen coupled with two adjacent axial hydrogens to give a triplet ($J_{aa} \simeq 11$ c.p.s.), each component of which is again split into a doublet by one adjacent equatorial hydrogen ($J_{ae} \simeq 4$ c.p.s.). Only in the *trans* isomers with the given conformation is the 1-hydrogen axial and adjacent to two other axial hydrogens and one equatorial hydrogen. The assignment is confirmed from the same spectra by the less clearly resolved multiplets (τ of 6.29 to 7.02) which in each case results from the axial hydrogen at C-2 being adjacent to two other axial hydrogens and one equatorial hydrogen. The *cis* configuration and the chair conformation with the aromatic group in equatorial orientation are established for those nitro compounds which give essentially a singlet for the hydrogen at C-1, and a doublet with evidence of further splitting for the hydrogen at C-2. The narrow signals (τ of 4.98 to 5.27) indicate that the hydrogen at C-1 is in an equatorial orientation. The signals of the hydrogen at C-2 (τ of 6.59 to 7.09) show that it has axial orientation and is adjacent to one axial and two equatorial hydrogens in each case. The signal is split into a doublet, $J_{aa} \simeq 11.5$ c.p.s., by the axial hydrogen at C-3 and each component of the doublet is split into a triplet by the equatorial hydrogens at C-1 and C-3, $J_{ae} \simeq 3.5$ c.p.s.

The interpretation is similar for the amines but there is more overlapping of signals, especially in the *ortho*-substituted compounds where the paramagnetic shift of the hydrogen at C-2 causes an overlapping of the signals of the 1- and 2-hydrogen.

(1) This investigation was supported in part by a PHS research grant, No. H-3843 (C1), from the National Heart Institute, Public Health Service, in part by a research grant from the State of Washington Initiative 171 funds for Research in Biology and Medicine, and in part by a research grant from the Smith Kline and French Laboratories. The n.m.r. spectra were determined by B. J. Nist, Department of Chemistry, University of Washington.

(2) Recipient of the Lunsford Richardson Pharmacy Award for a paper based on the material presented in this publication.

(3) J. A. Pople, W. G. Schneider, and H. J. Bernstein, "High-resolution Nuclear Magnetic Resonance," McGraw-Hill, 1959, pp. 387–399.

(4) R. M. Lemieux, R. K. Kullnig, H. J. Bernstein, and W. G. Schneider, *J. Am. Chem. Soc.*, **80**, 6098 (1958).

(5) (a) G. E. McCasland, S. Furuta, L. F. Johnson, and J. N. Schoolery, *ibid.*, **83**, 2335 (1961). (b) J. N. Schoolery, L. F. Johnson S. Furuta, and G. E. McCasland, *ibid.*, **83**, 4243 (1961).

(6) A. C. Huitric and J. B. Carr, *J. Org. Chem.*, **26**, 2648 (1961).

(7) A. C. Huitric, W. G. Clarke, Jr., K. Leigh, and D. C. Staiff, *ibid.*, **27**, 715 (1962).

(8) A. C. Huitric and W. F. Trager, *ibid.*, **27**, 1926 (1962).

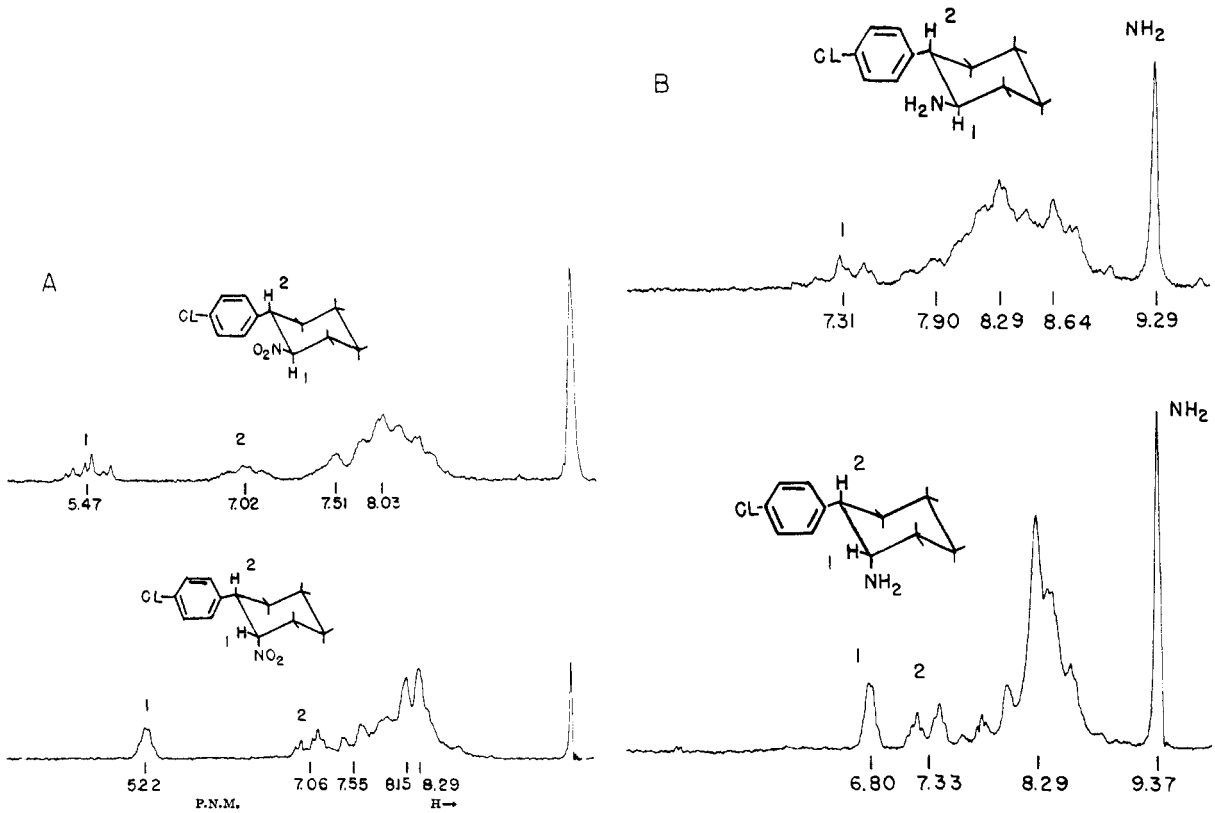


Fig. 1.—N.m.r. spectra of *trans*- and *cis*-2-(*p*-chlorophenyl)nitrocyclohexane and *trans*- and *cis*-2-(*p*-chlorophenyl)cyclohexylamine; 60 Mc. at 23°.

The area under the combined peaks at 6.78 for the *cis*-*o*-chloro and at 7.08 for the *cis*-*o*-tolyl compounds in each case accounts for the two hydrogens. Half of the signal of the 2-hydrogen is hidden under the singlet of the 1-hydrogen. The area under the signal at 7.26 for the *trans*-*o*-chloro compound also accounts for two hydrogens.

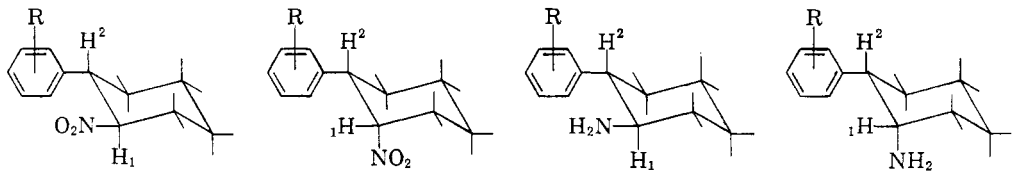
The chemical shift data indicate a greater deshielding of the hydrogen at C-2 for all stereoisomers when the aromatic substituent is in the *ortho* position compared to the corresponding *meta* and *para* isomers. A similar but smaller effect is observed for the 1-hydrogen of the *trans* isomers. This is in agreement with an analogous behavior observed in the corresponding cyclohexanols.[7] The effect is explained in terms of long range shielding effects of the benzene ring. Regions of positive and negative shielding have been mapped for the benzene ring.[9] Maximum negative shielding of the 2-hydrogens occurs when the phenyl ring is perpendicular to the plane of the cyclohexane ring. Approximately the same orientation of the phenyl ring is required for maximum deshielding of the 1-hydrogen in the *trans* isomers. Substituents in the *ortho* position hinder rotation of the phenyl group causing the two rings to remain more closely perpendicular to each other. The higher τ-value for the hydrogen on C-2 in any *trans* cyclohexylamine compared to its *cis* isomer is analogous to a similar effect observed with the corresponding cyclohexanols.[7] This suggests that the effect of the magnetic anisotropy of the C—N bond is to shield the 2-hydrogen in the *trans* isomers and deshield it in the *cis* isomers. In the nitro compounds the long range shielding effect of the nitro group[8] causes a greater deshielding of the 2-hydrogen in the *trans* than in the *cis* isomers.

A doublet with a separation of about 11.7 c.p.s. accounting for one hydrogen, appears at $\tau = 7.55$ in the spectra of the *meta*- and *para*-*cis*-2-(chlorophenyl)nitrocyclohexanes. A similar signal is partially hidden under the signal of the aromatic methyl group in the spectrum of *cis*-2-*p*-tolylnitrocyclohexane. From the previous observation of a negative shielding effect on the equatorial hydrogens at C-2 and C-6 in *cis*-4-*tert*-butylnitrocyclohexane,[8] such a signal is expected from the equatorial hydrogen on C-6 because of its location in a region of negative shielding brought about by the nitro group. the doublet arising from spin-spin coupling with the other geminal methylene hydrogen on C-6. The *ortho* isomers of the *cis* series show peaks in the same region but the pattern is more complex, indicating a downfield shift of more than one hydrogen in this region. Clarification of the peaks in this region is being sought through

(9) C. E. Johnson, Jr., and F. A. Bovey, *J. Chem. Phys.*, **29**, 1012 (1958).

TABLE I

CHEMICAL SHIFTS EXPRESSED IN τ-VALUES



Hydrogen	1	2	Ar	1	2	Ar	1	2	Ar	—NH_2	1	2	Ar	—NH_2
R = *p*-Cl	5.47	7.02	2.87	5.22	7.06	2.86	7.31	7.90	2.93	9.29	6.80	7.33	2.83	9.37
R = *m*-Cl	5.44	6.94	2.89	5.18	7.05	2.86	7.26	7.86	2.88	9.08	6.86	7.39	2.89	9.42
R = *o*-Cl	5.19	6.29	2.87	4.98	6.59	2.81	≃7.26	≃7.26	2.85	9.15	6.66	6.78	2.87	9.37
R = *p*-CH_3	5.47	6.98	3.01	5.22	7.09	3.01	7.30	...	2.98	9.28	6.86	7.39	3.02	9.40
R = *o*-CH_3	5.30	6.59	2.97	5.27	6.88	3.00	≃7.12	≃7.49	2.98	9.17	6.88	7.08	2.97	9.28

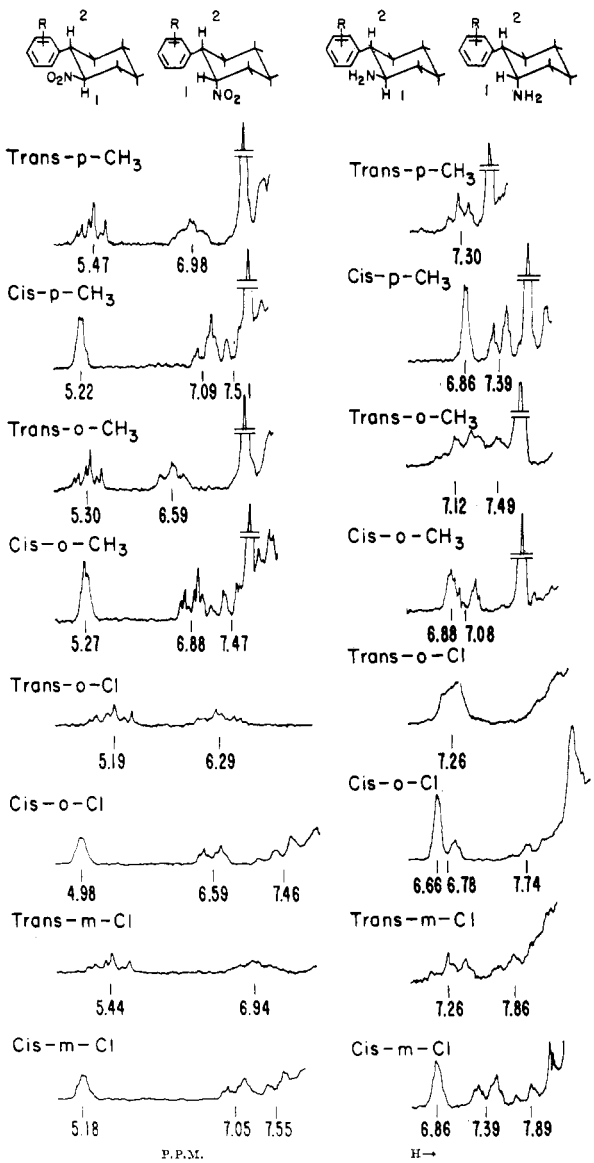


Fig. 2.—N.m.r. spectra showing the signals of 1- and 2-hydrogens of *trans*- and *cis*-2-arylnitrocyclohexanes and 2-arylcyclohexylamines; 60 Mc. at 23°.

selectively deuterated compounds. The spectra of the *cis* amino compounds also give peaks in the region of about 7.75 to 7.94. From their area it is obvious that these peaks represent only a few components of more complex multiplets. Clarification of these peaks is also being sought through deuterated compounds.

The n.m.r. spectra give direct experimental evidence that the 2-arylnitrocyclohexanes obtained from the Diels-Alder condensation of β-nitrostyrenes with butadiene, followed by hydrogenation of the double bond, using 10% palladium on carbon as a catalyst, are the *trans* isomers as expected from the *trans* styrenes. Treating *cis*-2-*o*-tolylnitrocyclohexane under the conditions used to reduce the double bond did not cause isomerization.

The configuration of 2-phenylcyclohexylamine isolated from the Raney nickel hydrogenation of the product of the Diels-Alder reaction of β-nitrostyrene and butadiene[10] has been established to be *trans* through synthetic methods by Arnold and Richardson.[11]

The *cis*-2-arylnitrocyclohexanes were prepared from the corresponding *trans* isomers by adding the *aci*-nitro compounds, obtained from the *trans* isomers, to a buffered system of sodium acetate and acetic acid in ethanol, a method similar to that described by Zimmerman and Nevins.[12] The acetate ion is basic enough to ionize the *aci*-nitro compounds but not sufficiently basic to ionize the nitro form. Under these conditions the protonation of the conjugate base of the substituted 2-phenylnitrocyclohexanes on the carbon atom is rate controlled and yields almost exclusively the thermodynamically least stable *cis* isomers. Recrystallization of the solid products yielded about 70% of theoretical of the *cis* isomers. No *trans* isomers were recovered. The nitro compounds were reduced stereoselectively to the corresponding amines by iron in acetic acid.[13] The amines were analyzed by gas chromatography using a five foot column of basic Carbowax 20 M. The amine obtained from the reduction of the liquid *cis*-2-(*m*-chlorophenyl)nitrocyclohexane was found to con-

(10) D. Nightingale and V. Tweedie, *J. Am. Chem. Soc.*, **66**, 1968 (1944).

(11) R. T. Arnold and P. N. Richardson, *ibid.*, **76**, 3649 (1954).

(12) H. E. Zimmerman and T. E. Nevins, *ibid.*, **79**, 6559 (1957).

(13) N. Kornblum, W. D. Gurowitz, H. O. Larson, and D. E. Hardies, *ibid.*, **82**, 3099 (1960).

TABLE II

cis-2-(SUBSTITUTED PHENYL)NITROCYCLOHEXANES

	Substituent	M.p.	Yield, %	Calculated C	Calculated H	Calculated N	Found C	Found H	Found N
III	*p*-Chloro[a]	69–70°	68	60.13	5.89	5.84	60.48	5.76	5.57
IV	*m*-Chloro[b]	...	70	60.13	5.89	5.84	60.20	6.05	5.56
V	*o*-Chloro	84.7–85.5°	68	60.13	5.89	5.84	59.93	6.11	5.58
VI	*p*-Methyl[c]	78–78.5°	70	71.20	7.82	6.39	71.25	7.62	6.56
VII	*o*-Methyl	58–58.5°	69	71.20	7.82	6.39	70.91	7.83	6.58

[a] Compounds III and V were recrystallized from *n*-hexane. [b] Compound IV is a liquid b.p. 120° at 0.18 mm. [c] Compounds VI and VII were recrystallized from a mixture of ethanol and water.

TABLE III

cis- AND *trans*-2-(SUBSTITUTED PHENYL)CYCLOHEXYLAMINES

	Substituent	M.p.	B.p.	Yield, %	M.p. of hydrochloride salt	Analysis of hydrochloride salt: Calculated C	Calculated H	Calculated N	Found C	Found H	Found N
VIII	*trans*-*p*-Methyl[a]	71.5–72.5°	92° at 0.21 mm.	56	266–267°	69.16	8.93	6.20	69.14	8.43	6.38
IX	*cis*-*p*-Methyl[b]	43.5°	80° at 0.20 mm.	57	206.5–208.5°	69.16	8.93	6.20	69.27	8.94	6.18
X	*trans*-*o*-Methyl		72° at 0.26 mm.	73	233–233.5°	69.16	8.93	6.20	68.99	8.84	6.13
XI	*cis*-*o*-Methyl		98° at 0.55 mm.	35	224–225°	69.16	8.93	6.20	69.31	8.99	6.44
XII	*trans*-*p*-Chloro[c]	65.5–66.5°		48	Sublimes	58.55	6.96	5.69	58.52	6.96	5.81
XIII	*cis*-*p*-Chloro		96° at 0.32 mm.	47	Sublimes	58.55	6.96	5.69	58.76	7.25	5.67
XIV	*trans*-*m*-Chloro		93° at 0.35 mm.	53	244.5–245°	58.55	6.96	5.69	58.44	6.73	5.42
XV	*cis*-*m*-Chloro[d]		84° at 0.17 mm.	57	197–198.5°	58.55	6.96	5.69	58.30	6.90	5.90
XVI	*trans*-*o*-Chloro[e]		86° at 0.3 mm.	83	193.5–194°	58.55	6.96	5.69	58.87	6.98	5.67
XVII	*cis*-*o*-Chloro[f]		90° at 0.22 mm.	57	270–271°	58.55	6.96	5.69	58.58	7.05	5.58

[a] The free amines of compounds VIII and IX were recrystallized from a mixture of ethanol and water. The hydrochloride salts of compounds VIII, X, XI and XIV were recrystallized from a mixture of isopropyl alcohol and hexane. [b] The hydrochloride salt of compound IX was recrystallized from a mixture of benzene and hexane. [c] The free amine of compound XII was recrystallized from *n*-hexane. The hydrochloride salts of compounds XII and XIII were recrystallized from absolute ethanol. [d] The hydrochloride salt of compound XV was recrystallized from isopropyl alcohol. [e] The hydrochloride salt of compound XVI was recrystallized from benzene. [f] The hydrochloride salt of compound XVII was recrystallized from a mixture of isopropyl alcohol and ethanol.

tain a small amount (less than 5%) of the *trans* isomer. No *trans* amines were detected in the reduction product of the pure *cis* solid nitro compounds.

Reduction of *trans*-2-(*p*-chlorophenyl)nitrocyclohexane and *trans*-2-(*m*-chlorophenyl)nitrocyclohexane with lithium aluminum hydride in ethyl ether yielded in each case a mixture of about 50:50 *cis* and *trans* isomers.

The 2-arylcyclohexylamines were found to give a crystalline precipitate when dissolved in carbon tetrachloride. Tetrachloroethylene was therefore used as a solvent for n.m.r. Collins[14] has reported isolation of cyclohexylamine hydrochloride from solutions of cyclohexylamine in carbon tetrachloride.

Experimental

trans-*o*-**Methyl**-β-**nitrostyrene.**—This compound was obtained in 73% yield by the method described for β-nitrostyrene[15]; b.p. 106° at 0.35 mm.

Anal. Calcd. for $C_9H_9NO_2$: C, 66.24; H, 5.56. Found: C, 66.62; H, 5.54.

trans-**4-Nitro-5-tolylcyclohexenes.**—These compounds were prepared by the method of Wildman and Wildman[16] by heating 20 g. of the appropriate β-nitrostyrene with about 20 ml. of condensed butadiene, 30 ml. of toluene, and a trace of hydroquinone in a pyrex bomb at 110° for 6–7 days. The yield of purified products, recrystallized from isopropyl alcohol, was about 70%.

Isomers	M.p.	Analysis: Calculated	Found
p-Tolyl	89–90.5°	C, 71.87	71.81
		H, 6.96	7.12
		N, 6.45	6.61
o-Tolyl	78–78.5	C, 71.87	71.68
		H, 6.96	6.96
		N, 6.45	6.52
I *p*-Tolyl	73–74°	C, 71.20	71.62
		H, 7.81	7.74
		N, 6.40	6.59
II *o*-Tolyl	66–67°	C, 71.20	71.50
		H, 7.81	7.69
		N, 6.39	6.40

trans-2-**Tolylnitrocyclohexane.**—These compounds were obtained by low pressure catalytic hydrogenation of the corresponding cyclohexenes using 10% palladium on carbon in ethyl acetate.[7]

cis-2-(**Substituted Phenyl**)**nitrocyclohexanes.**—The method used to convert the *trans*-2-(substituted phenyl)-nitrocyclohexanes[17] to the corresponding *cis*-2-(substituted phenyl)nitrocyclohexanes is essentially that of Zimmerman and Nevins.[12] The preparation of *cis*-2-(*p*-chlorophenyl)-nitrocyclohexane is given as a typical example of the method. The analysis and physical constants of the products appear in Table II.

cis-2-(*p*-**Chlorophenyl**)**nitrocyclohexane.**—Five grams (0.021 moles) of *trans*-2-(*p*-chlorophenyl)nitrocyclohexane

(14) K. F. Collins, *Chem. Ind.* (London), 704 (1957).

(15) D. E. Worrall, "Organic Syntheses," Vol. I, 2nd ed., John Wiley & Sons, New York, 413.

(16) W. C. Wildman and R. B. Wildman, *J. Org. Chem.*, **17**, 581 (1952).

(17) The *ortho*-, *meta*-, and *para*-*trans*-2-(chlorophenyl)nitrocyclohexanes are reported in ref. 7.

was converted to the soluble potassium salt by swirling in 24 ml. of 10% ethanolic potassium hydroxide solution. The clear yellowish solution was diluted with a 100 ml. of ethanol and 250 ml. of water, then cooled with stirring in a Dry Ice–methanol bath to approximately −12°. The solution was then acidified with a 1:3 sulfuric acid–ethanol solution to a Congo Red end point. The resulting colorless solid precipitate was filtered and transferred at once to 500 ml. of a buffer solution prepared in the following ratio: 100 ml. of 95% ethanol, 7.5 g. (0.055 mole) of sodium acetate (trihydrate), and 0.5 ml. of glacial acetic acid. The mixture was allowed to stand for approximately 20 min. after which time it was diluted with 1 l. of water. The resulting milky suspension was extracted with ether and the ethereal extract washed twice with a saturated sodium bicarbonate solution and once with water. The ethereal extract was dried over calcium sulfate, the ether evaporated, and the product recrystallized from *n*-hexane.

***trans*- and *cis*-2-(Substituted Phenyl)cyclohexylamines.**—These compounds were prepared by the stereospecific reduction of the corresponding nitro compounds according to the method of Kornblum, Gurowitz, Larson, and Hardies.[13] An example of this method is given below. The analysis and physical constants of the products appear in Table III.

***trans*-2-*p*-Tolylcyclohexylamine.**—Twenty-five grams of finely powdered, hydrogen-reduced iron was washed with 5% hydrochloric acid, the acid decanted, and the powder rinsed twice with glacial acetic acid. The iron powder was then slurried with 150 ml. of glacial acetic acid and the slurry transferred to a 1-l. three-neck flask. Fifteen grams (0.068 mole) of *trans*-2-*p*-tolylnitrocyclohexane (I) dissolved in 50 ml. of hot glacial acetic acid was added, with stirring, to the glacial acetic acid–iron powder mixture. The reaction mixture was refluxed for 3 hr., cooled, and filtered with suction through a Celite pad. The filtrate was made basic to pH of about 10 by slow addition of 30% sodium hydroxide solution with stirring and cooling. The mixture was exhaustively extracted with ether, dried over calcium sulfate, the ether evaporated, and the product distilled under reduced pressure.

Hydrochloride Salts.—The various salts were prepared by bubbling hydrogen chloride gas into a solution of the particular amine in hexane. The salt was filtered and recrystallized from an appropriate solvent.

The n.m.r. of all the nitrocyclohexanes were determined in a carbon tetrachloride solution containing 1% tetramethylsilane (100 mg. of compound in 0.5 ml. of solution).

The n.m.r. of all the cyclohexylamines were determined at the same concentrations but tetrachloroethylene was used as the solvent.

The melting points were determined with a Kofler micro hot state.

Rates of Saponification of Some Halogen-Substituted Ethyl Phenoxyacetates[1]

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The rates of hydrolysis by sodium hydroxide in 87.5 weight per cent aqueous ethanol have been measured at 0 and 30° of ethyl phenoxyacetate and the 2- and 4-fluoro, chloro, bromo, and iodo and the 2,4-difluoro, dichloro, dibromo, and diodo substituted esters and found to be surprisingly rapid, ranging between 0.043 and 0.115 at 0° and 0.51 and 1.39 at 30° in the second-order rate constant. The Hammett equation was not followed although the rate constants at 0° for the 4-halo esters gave a rough fit to σ°. The rate parameters were calculated and a linear enthalpy-entropy of activation relationship was shown to exist. A re-interpretation of Leffler's equation[10] has been made, and of the requirements for adherence to the Hammett relationship.

The chemistry of the halogen-substituted phenoxyacetic acids has become of interest because of the problem of finding a correlation between the plant growth or biological activity and the chemical properties.[2] A halogen in the 4-position, specially fluorine or chlorine, seems to be necessary for any appreciable activity which is enhanced by further substitution in the 2-position. We wish to report the results of a study of the saponification of a series of halogen-substituted ethyl phenoxyacetates in 87.5 weight per cent aqueous ethanol.

Rate constants were calculated from the usual second-order rate expression. Except for some instances at 0° when the initial point fell below the straight line in a plot of log $(x + c)/x$ *vs.* time, or at 30° when the initial point fell above the plotted line, the reaction rates were straightforward. In Table I the results are given along with the values of the rate parameters calculated in the usual way. The rates turned out to be rather fast with log A factors comparable to those for the basic hydrolysis of ethyl benzoates in 85% ethanol[3] and activation energies comparable to aliphatic ester hydrolysis.[3] Substitution of halogen increase the rate in every instance. Since the phenoxy group possesses an $-I$ effect, and since the halogens all have an $-I$ effect greater than an $+M$ effect, the increases were as expected.

Since the basic hydrolysis of ethyl benzoates in 87.83% ethanol follows the Hammett equation[4] with $\rho = 2.498$; of ethyl phenylacetates[5] with

(1) This work was supported by a contract with the U.S. Army Chemical Corps, Fort Detrick, Frederick, Maryland. It is based in part on a dissertation submitted by H. C. Newsom to the Graduate School of the University of Southern California in partial fulfillment of the requirements for the Ph.D. degree.

(2) See for example, R. L. Weintraub, J. W. Brown, and J. A. Thorne, *J. Ag. Food Chem.*, **2**, 996 (1954); R. F. Brown and E. F. Claflin, *J. Am. Chem. Soc.*, **80**, 5960 (1958); A. M. Johnston, *J. Chem. Soc.*, 2335 (1961).

(3) E. A. Moelwyn-Hughes, "Kinetics of Reactions in Solution," Clarendon Press, Oxford, 1947, pp. 141, 149.

(4) L. P. Hammett, *J. Am. Chem. Soc.*, **59**, 96 (1937); K. Kindler, *Ann.*, **450**, 1 (1926); **452**, 90 (1927); **464**, 278 (1928); and *Ber.*, **69B**, 2792 (1936).

(5) H. H. Jaffe, *Chem. Rev.*, **53**, 191 (1953), reaction number 53.