Table I

Relative Rates

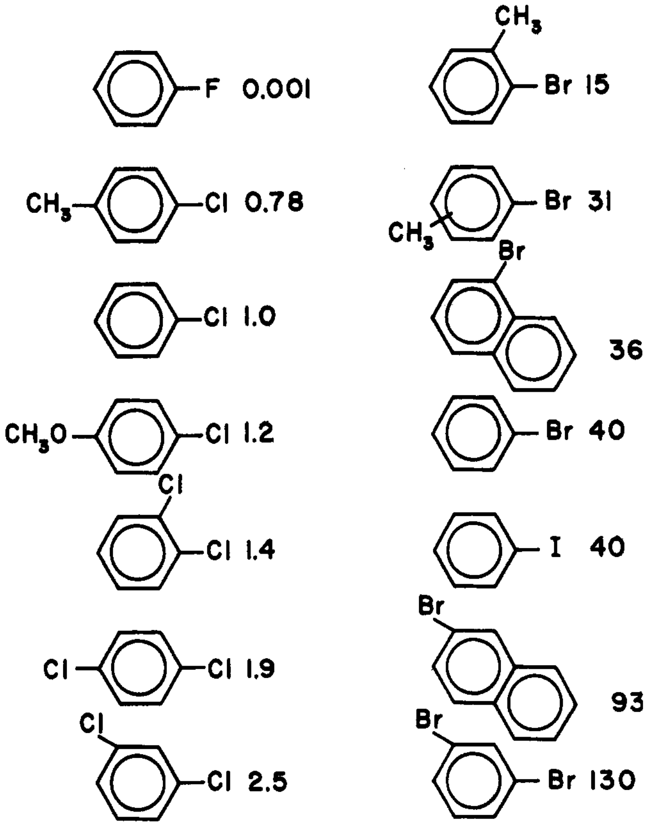

Table II

Halogen Mobilities[a]

Reaction type	I	Br	Cl	F
Ullmann condensation	40[b]	40	1	~10^{-3}
E2	190	41	1	
S_N2	80	30 to 40	1	
S_N1	100	25 to 60	1	~10^{-5}

[a] The data for E2, S_N2, and S_N1 reactions were obtained from C. K. Ingold, "Structure and Mechanism in Organic Chemistry," Cornell University Press, Ithaca, N. Y., 1953, p. 339. [b] More precise kinetic measurements show the I:Br ratio to be about 3.

aromatic substitution. We believe these results point to a rate-determining step involving carbon–halogen bond cleavage. Our data are summarized in Table II and are compared with similar data for reactions known to involve carbon–halogen bond cleavage in the rate step.

Experimental

Competitive Reactions.—In a flask equipped with a stirrer, condenser (fitted with azeotrope adapter), thermometer, and gas inlet were placed 0.025 mole of KOH, 0.05 mole of phenol, and 10 ml. of toluene. The mixture was heated under a small nitrogen flow at 100–115° until all of the water was removed. To this mixture was added 10 ml. of diglyme (practical grade[8]) and 0.1 mole each of the haloaromatics (usually two), followed by 0.1 g. of $CuCl_2$. The solution was then refluxed at 160° for 15 hr. The reaction mixture was poured into ice–water, extracted into CCl_4, dried, and the CCl_4 solution was used directly for gas chromatographic analysis.

The following runs were made and are reported with corrected product ratios: fluorobenzene *vs.* *p*-chlorotoluene 1:~1000, chlorobenzene *vs.* *p*-bromotoluene 1:31, iodobenzene *vs.* *p*-bromotoluene 1:0.77, chlorobenzene *vs.* *p*-chloroanisole 1:1.2, bromobenzene *vs.* *p*-bromotoluene 1:0.78, chlorobenzene *vs.* *p*-dichlorobenzene 1:1.9, bromobenzene *vs.* *m*-dibromobenzene 1:3.2, bromobenzene *vs.* α-bromonaphthalene 1:0.9, α-bromonaphthalene *vs.* β-bromonaphthalene 1:2.6, *o*, *m*-, and *p*-bromotoluene 1:2:2, *o*-, *m*-, and *p*-dichlorobenzene 1:1.7:1.3.

Gas Chromatographic Analysis.—The gas chromatographic analyses were performed on an F and M Model 1720 instrument equipped with a 1 m. × 0.25 in. column packed with Anakrom ABS (50–60 mesh) impregnated with 2% *m*-bis[*m*-(*m*-phenoxyphenoxy)phenoxy]benzene. The column temperature was programmed between 100 and 300°, the detector block containing a hot filament was kept at 285°, and the injection block was kept at 287°. The eluent was helium, the flow rate was 30 ml./min., and the pressure was maintained at 50 p.s.i.g.

An Ott compensating planimeter was used to measure peak areas, and standard mixtures were run concurrently to provide correction factors.

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[8] Matheson, Coleman and Bell.

The Facile Isomerization of 4-Methylene-2-oxazolidinones to 4-Methyl-4-oxazolin-2-ones

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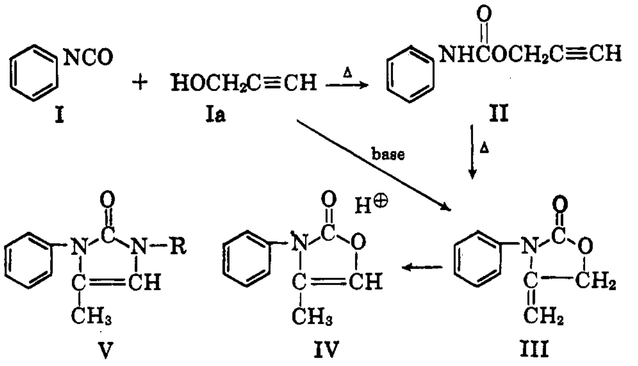
We have shown that heating propargyl alcohol with phenyl isocyanate to 65° gave the carbanilate (II). Furthermore, heating the same reactants or the preformed carbanilate (II) to 160° gave the cyclized 4-methylene-2-oxazolidinone[1] (III). Other investigators obtained III directly from I and Ia using catalytic amounts of pyridine,[2] sodium acetate,[3,4] potassium hydroxide,[5] and sodium methoxide.[6] This did not seem reasonable since we have shown that the treatment of propynylureas with strong acid or strong base gave the 4-methyl-imidazolin-2-one[7,8] (V) containing an endocyclic double bond in contrast to the exocyclic double bond of III. It was equally puzzling to note that Sisido, *et al.*,[5] obtained the endocyclic analog (IV) in the reaction of I and Ia with base, but a footnote states



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[1] P. J. Stoffel and A. J. Speziale, *J. Org. Chem.*, **28**, 2814 (1963); **28**, 2917 (1963).

[2] M. D. Cameron, U. S. Patent 2,844,590 (July 22, 1958).

[3] S. L. Shapiro, V. Bandurco, and L. Freedman, *J. Org. Chem.*, **26**, 3710 (1961).

[4] N. R. Easton, D. R. Cassady, and R. D. Dillard, *ibid.*, **27**, 2927 (1962).

[5] R. Sisido, K. Hukuoka, M. Tuda, and H. Nozaki, *ibid.*, **27**, 2663 (1962).

[6] N. Shachat and J. J. Bagnell, Jr., *ibid.*, **28**, 991 (1963).

[7] P. J. Stoffel and A. J. Speziale, *J. Am. Chem. Soc.*, **84**, 501 (1962).

[8] P. J. Stoffel and A. J. Speziale, *J. Org. Chem.*, **27**, 3079 (1962).

that they also obtained III in one experiment, which they could not repeat in subsequent attempts.

We now wish to report that heating I with strong acids as catalysts to 185° gives only the carbanilate (II) and no cyclized product (III or IV). The addition of excess base readily converts II to III with no appearance of IV. Now, however, on adding acid, III is quantitatively converted to IV. In all cases, III must be formed prior to the isomerization to IV.

We assigned the structure[1] of III by n.m.r. spectrum which showed a singlet at τ 2.75, a triplet at 5.05, and a quartet at 5.85 with an intensity ratio of 5:2:2 (m.p. 97.1–97.8°). After treatment with acid, the n.m.r. spectrum showed a singlet at τ 2.75, a quartet at 3.40, and a doublet at 8.15 with an intensity ratio of 5:1:3 (m.p. 56.5–57.2°). This product (IV) has the same melting point and the same n.m.r. spectrum of that reported by Shachat, *et al.*,[6] as a minor product in the preparation of III.

We note that Sisido, *et al.*,[5] neutralized with excess acid during the work-up of their product which accounts for the isolation of IV in all cases but one. Shachat, *et al.*,[6] used "just sufficient acid to neutralize the base,[1]" but even so this would probably account for a minor amount of IV found. A similar acid-catalyzed isomerization has been reported in the related triazole series.[9,10]

Experimental

4-Methylene-3-phenyl-2-oxazolidinone (III).—A solution of phenyl isocyanate (11.9 g., 0.1 mole), propargyl alcohol (5.6 g., 0.1 mole), and sodium acetate (0.1 g.) was stirred until a strongly exothermic reaction had subsided. Two recrystallizations from methanol gave small white granules, m.p. 97.2–97.5°; the yield was 82.5%.

Anal. Calcd. for $C_{10}H_9NO_2$: C, 68.6; H, 5.18; N, 8.00. Found: C, 68.4; H, 5.22; N, 8.11.

The same compound was obtained using pyridine, potassium hydroxide, or by heating to 160° without catalyst.

4-Methyl-3-phenyl-4-oxazolin-2-one (IV).—One-gram samples of III were dissolved in sulfuric, *p*-toluenesulfonic, and trifluoroacetic acids. Dilution with water or evaporation on a Rinco evaporator gave the isomerized product. Recrystallization from hexane gave soft white plates, m.p. 56.5–57.2°.

Anal. Calcd. for $C_{10}H_9NO_2$: C, 68.6; H, 5.18; N, 8.00. Found: C, 68.5; H, 5.21; N, 8.06.

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[9] Y. Yura, *Chem. Pharm. Bull.* (Tokyo), **10**, 1087 (1962).

[10] W. Batty and B. Weedon, *J. Chem. Soc.*, 786 (1949).

The Effect of Ionic Structure on the Hydrogenation of 1-Methyl-4-(2,2-diphenyl-2-hydroxyethyl)piperazine

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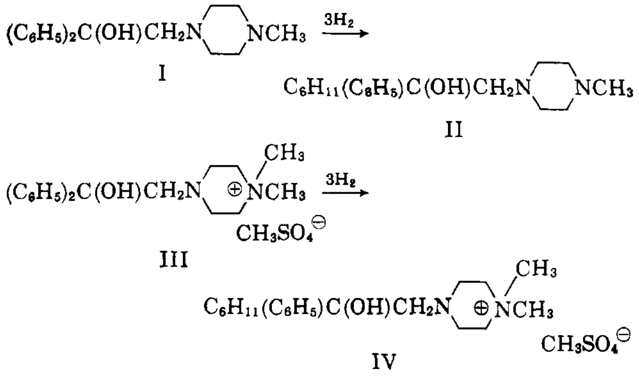
Maxted has discussed the poisoning effect of nitrogen bases on catalytic hydrogenation and the means of overcoming it by converting the offending atom to an ionic or shielded form.[1] It, therefore, appeared of interest to study the reduction of 1-methyl-4-(2,2-diphenyl-2-hydroxyethyl)piperazine (I) as acid salt or quaternary salt to determine whether there is any difference in the protective effect of the two ionic forms.



Results of the hydrogenation studies are summarized in Table I. It is evident that, despite the large group at N⁴ which may prevent poisoning to some extent, more rapid and more complete reaction takes place when sufficient acid is present to neutralize that nitrogen atom. A comparison of reduction B, where the dihydrochloride salt is partially neutralized to the monohydrochloride salt, and reduction D seems to give an indication that quaternization gives better protection against poisoning. This is more clearly indicated in the attempts to reduce both rings with platinum oxide. No success was achieved with the dihydrochloride salt of I. In contrast when III is hydrogenated in the presence of acid to neutralize the N^4 atom, 1,1-dimethyl-4-(2,2-dicyclohexyl-2-hydroxyethyl)piperazinium methosulfate V is obtained in good yield. This shows that the difficulty in converting both rings is due to partial poisoning, not geometry. Hydrogenation results also indicate that rhodium catalysts are less sensitive to base effect than platinum.

TABLE I

HYDROGENATION CONDITIONS[a]

Experiment	Substrate	Catalyst	Ratio, %	Time, hr.	Product	Yield, %
A	I[b]	[f]	3		II	85
B	I[b,c]	[f]	3	[i]	II	84
C	I[b,d]	[g]	7	7	II	80
D	III	[f]	5	20	IV	78
E	III[e]	[f]	2.5	20	IV	80
F	III	[h]	35	14[j]	IV	84
G	III[e]	[h]	35	6	IV	85

[a] Except where noted, hydrogenations were carried out at 55–60° and 2-atm. pressure with 0.03 mole of substrate in 3.0 ml. of water. [b] Dihydrochloride salt used, pH of solution 1.5. [c] Solution adjusted to pH 3.0 by the addition of sodium hydroxide solution. [d] pH of solution changed to 4.0–5.0. [e] Three cubic centimeters of acetic acid added. [f] Platinum oxide. [g] 5% rhodium on alumina. [h] 5% rhodium on carbon. Reduction carried out at room temperature. [i] Uptake of hydrogen only 30% in 20 hr. When the pH of the solution was lowered to 1.5 by the addition of hydrochloric acid the rate of uptake increased markedly. Reduction was complete in 6 hr. more. [j] Uptake was 70% in 5–6 hr.

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[1] E. B. Maxted, "Advances in Catalysis," Vol. III, Academic Press, Inc., New York, N. Y., 1951.

[2] Examination of molecular models of I and II shows that one of the benzene rings is generally out of plane, but they can be rotated so that both rings will make contact with the catalyst surface.