

68% yield from benzhydrol and hydrogen chloride in dry ether, essentially by the method of Montagne.⁴

Benzhydryl Nitrate.—Twenty-six grams (0.13 mole) of the chloride was dissolved in 35 ml. of anhydrous ether and the solution was stirred for ten hours with 30 g. of powdered silver nitrate, while precautions were taken to exclude moisture. The silver chloride and excess silver nitrate were filtered and washed with dry ether. The filtrate was chloride-free, as indicated by testing with alcoholic silver nitrate. After distillation of the ether at reduced pressure, there remained 25 g. (0.11 mole, assuming pure benzhydryl nitrate) of a rather viscous yellow liquid. Trial runs had shown that the nitrate decomposed on attempted distillation, with the evolution of NO₂. This residual liquid was therefore used without any purification. The liquid gave a strong brown-ring test for nitrate with ferrous sulfate and sulfuric acid, and the infrared spectrum showed strong absorption peaks, characteristic of nitrate esters, at 6.06 and 7.82 μ .

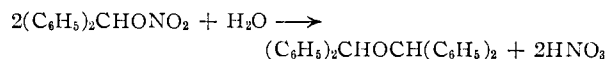
A sample was analyzed immediately after distillation of the ether. *Anal.* Calcd. for C₁₃H₁₁NO₃: C, 68.11; H, 4.84. Found: C, 69.76; H, 5.30.

On standing for an hour at room temperature or overnight at 0°, in stoppered flasks, the nitrate decomposed, giving a quantitative yield of dibenzhydryl ether, m.p. 107–108° (lit.⁵ 109–109.5°).

Anal. Calcd. for C₂₆H₂₂O: C, 89.11; H, 6.33; N, 0.00. Found: C, 88.78; H, 6.17; N, 0.00. The infrared spectrum of this material did not show absorptions at 6.06 and 7.82 μ .

Treatment of the nitrate with 95% hydrazine resulted in some gas evolution, heating and reddening, which varied from one run to another, and which may have been due to oxides of nitrogen present as a result of partial autodecomposition of the nitrate. In every trial, however, dibenzhydryl ether was formed in good yield in a few minutes at room temperature. The ether was also formed, but more slowly, when small amounts of the nitrate were added to ethanol, methanol or water.

To establish the stoichiometry of the hydrolysis of benzhydryl nitrate, the following procedure was used. The chloride-free ether solution of the nitrate ester made from 12.0 g. (59.11 mmoles) of benzhydryl chloride was added to 120 ml. of water, and the mixture was stirred and warmed to remove the ether. After four hours additional stirring, the layers were separated and the aqueous solution titrated for acidity with standard NaOH. The non-aqueous material was stirred for eight hours with another portion of water, and the layers separated and treated as before. After a third 8-hour treatment, the non-aqueous material was entirely crystalline, and was filtered, washed with ethanol and dried *in vacuo*. Total acidity in the combined aqueous solutions was 43.75 milliequivalents. Weight of the solid dibenzhydryl ether, m.p. 107–108°, was 7.75 g. (22.14 mmoles). This indicated approximately 75% conversion of chloride to nitrate ester, and further indicated that the stoichiometry of the hydrolytic reaction could be represented as



Triphenylmethyl Nitrate.—To a solution of 2.0 g. (0.0072 mole) of trityl chloride in 30 ml. of anhydrous ether was added 2.0 g. (0.12 mole) of powdered silver nitrate. The mixture was stirred overnight, with precautions taken to exclude moisture. The silver chloride was filtered off, and the filtrate was found to be chloride free. The ether was evaporated at water aspirator pressure. A white solid crystallized as the volume of solution decreased, and turned yellow and finally orange as the ether was completely evaporated. The original white solid melted with decomposition at 90–91°. The yield of the orange-yellow solid was 2.2 g. (100% if assumed to be pure trityl nitrate). The original white solid gave a brown-ring nitrate test. No analysis was possible because of the extreme instability of this ester.¹ Triphenyl carbinol, m.p. 160–161°, was isolated when a sample of this compound was refluxed for a

(4) P. J. Montagne, *Rec. trav. chim.*, **25**, 379 (1907).

(5) C. M. Welch and H. A. Smith, *THIS JOURNAL*, **72**, 4748 (1950).

(6) The melting point sample was obtained by dipping a capillary into the white solid beneath the surface of the ether, so that the solid was not exposed to the air until it was in the melting point tube.

few minutes in either anhydrous benzene or anhydrous carbon tetrachloride. The melting point was not depressed by mixing with an authentic sample of the carbinol.

When 95% hydrazine was dropped slowly onto solid trityl nitrate, a violent reaction took place, and only a dark red tarry residue was obtained. When the hydrazine was added to an ether suspension of the nitrate, the mixture became cloudy and warmed sufficiently to reflux the ether. After one hour, a small amount of white solid had precipitated. It first melted at 194–195° dec. after softening at 188°. After purification by recrystallization from benzene-ethanol, followed by washing with ether, the m.p. was 206–207° (uncor.). An authentic sample of 1,2-bis-(triphenylmethyl)-hydrazine prepared by the method of Wieland⁷ melted at 207–208°; there was no depression of the m.p. on mixing with the product from the trityl nitrate-hydrazine reaction.

Anal. Calcd. for C₃₈H₃₂N₂: C, 88.33; H, 6.24; N, 5.42. Found: C, 88.01, 88.26; H, 5.50, 5.35; N, 5.90.

(7) H. Wieland, *Ber.*, **42**, 3020 (1909).

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Further Investigation of the Solvolytic Reactivity of Nortricyclyl, Dehydronorbornyl and Norbornyl Halides¹

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In a previous paper,³ we reported solvolytic reactivities in 80% ethanol–20% water (by volume) of nortricyclyl (I), *endo*-dehydronorbornyl (II), *exo*-dehydronorbornyl (III), *endo*-norbornyl (IV) and *exo*-norbornyl (V) halides. In subsequent publications,⁴ it was shown that the ratios of the reactivities of the *endo*-compounds II and IV to those of the *exo*-compounds III and V are much greater with the *p*-bromobenzenesulfonates than reported³ for the corresponding halides.

We have prepared new samples of the chlorides II and IV and redetermined their solvolytic reactivities. The results (Table I) are in reasonable agreement with those obtained for the *p*-bromobenzenesulfonates⁴ and these chlorides are far less reactive than previously reported.³ The earlier erroneous results were due to insufficient reaction times and the presence of reactive impurities other

TABLE I

SOLVOLYSIS RATES OF CHLORIDE (RCl) IN 80% ETHANOL–20% WATER (BY VOLUME) SOLUTION AT 85.0 ± 0.1°

R	k ₁ , hr. ⁻¹	% Purity ^a (approx.)
Nortricyclyl (I)	0.019	100
<i>endo</i> -Dehydronorbornyl (II)	< .0005	83
<i>exo</i> -Dehydronorbornyl (III)	.078 ^b	83 ^b
<i>endo</i> -Norbornyl (IV)	~ .002	84
<i>exo</i> -Norbornyl (V)	.14 ^b	100 ^b

^a Determined by the method of H. C. Brown and R. S. Fletcher, *THIS JOURNAL*, **71**, 1845 (1949). ^b Ref. 3.

(1) Supported in part by the program of research of the U. S. Atomic Energy Commission under Contract AT(30-1)-905.

(2) Gates and Crellin Laboratories, California Institute of Technology, Pasadena 4, Calif.

(3) J. D. Roberts, W. Bennett and R. Armstrong, *THIS JOURNAL*, **72**, 3329 (1950).

(4) (a) S. Winstein, H. M. Walborsky and K. Schreiber, *ibid.*, **72**, 5795 (1950); (b) S. Winstein, B. K. Morse, E. Grunwald, H. W. Jones, J. Corse, D. S. Trifan and H. Marshall, *ibid.*, **74**, 1127 (1952).

than chlorides II and V. There is every reason to believe that similar difficulties were encountered for the corresponding *endo*-bromo derivatives.

As a further check on the reactivity of the nortricycyl halides, the pure chloride I has been prepared and it was found that this material was about one-seventh as reactive as chloride V. Bromide I is about one-tenth as reactive as bromide V.³ Chloride I solvolyses at very nearly the same rate as cyclopentyl chloride and about 1/50 to 1/100 as fast as cyclopropylcarbinyl chloride. The reactivity sequence is now: cyclopropylcarbinyl chloride > V > III > I ~ cyclopentyl chloride > IV > II.

The earlier conclusion³ regarding the driving force contributed by the double bond in the solvolyses of III can now be disputed on the basis that III is actually much more reactive than II irrespective of its reactivity relationship to V. The low reactivity of I relative to what might have been expected from the extraordinary reactivity of cyclopropylcarbinyl chloride⁵ may be interpreted as resulting from (1) steric inhibition of conjugation,³ (2) the unusual character of the carbonium ion intermediate formed in the solvolysis of cyclopropylcarbinyl derivatives,⁶ or (3) differences in the degree of relief of strain in the formation of the solvolysis transition states from the respective chlorides.

Experimental

Dehydronorbornyl Chloride.—A total of 120 g. of cyclopentadiene and 120 ml. of liquid vinyl chloride was heated for 14 hours in glass tubes at 170°. The reaction products were fractionated through a 1-m. glass-helix packed column and had b.p. 66–70° (40 mm.), n_D^{25} 1.4914–1.4932. A heart-cut of 31 g., b.p. 69–70° (40 mm.), n_D^{25} 1.4927, was used for the rate runs and preparation of *endo*-norbornyl chloride.

***endo*-Norbornyl Chloride.**—Hydrogenation of 20 g. of *endo*-dehydronorbornyl chloride was complete in an hour over platinum oxide in ethyl acetate at room temperature and atmospheric pressure. The product was distilled through a glass-helix packed column and had b.p. 75° (41 mm.). All of the fractions solidified and the material used for the rate runs had m.p. 34–36° (previously reported² 28°).

Nortricycyl chloride was prepared by isomerization of *endo*-dehydronorbornyl chloride. The adduct (50 g.) of cyclopentadiene and vinyl chloride was refluxed with 1 g. of anhydrous zinc chloride for five minutes. The mixture was cooled, shaken with water, dried over potassium carbonate, and distilled. The crude product amounted to 34 g. and had b.p. 160–170°. Quantitative hydrogenation indicated that about 60% of the crude product was nortricycyl chloride. The remaining unsaturated material was removed by shaking the crude products with sodium permanganate solution until no further reaction occurred. The residual saturated chloride had b.p. 60.4–61.0° (32 mm.), n_D^{25} 1.4947–1.4948. The infrared spectrum of the material used in the rate runs is given in Fig. 1. The strong infrared ab-

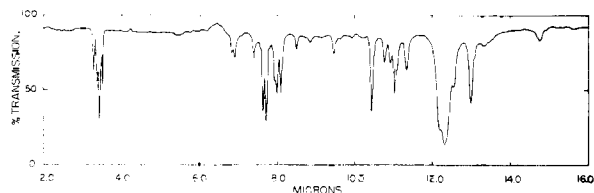


Fig. 1.—Infrared spectrum of nortricycyl chloride, 50 mg. in 0.50 ml. of CS₂ except in the region 4.2–5.0 and 6.2–7.4 μ where CCl₄ was the solvent.

(5) J. D. Roberts and R. H. Mazur, *THIS JOURNAL*, **73**, 2509 (1951).

(6) J. D. Roberts and R. H. Mazur, *ibid.*, **73**, 3542 (1951).

sorption in the neighborhood of 12.5 μ is typical of nortricycylene derivatives.⁷

Anal. Calcd. for C₇H₉Cl: C, 65.38; H, 7.05. Found: C, 65.71; H, 7.02.

Solvolysis rate measurements were made as previously described.³ Attempts to obtain more accurate rate constants for the less-reactive chlorides by extrapolation from higher temperatures were unsuccessful since at 105° the reaction of hydrochloric acid with 80% ethanol was comparable to the rate of solvolysis. The rate constants for the runs at 85.0 ± 0.1° are summarized in Table I.

(7) J. D. Roberts, E. R. Trumbull, Jr., W. Beunett and R. Armstrong, *ibid.*, **73**, 3116 (1950).

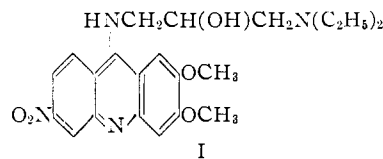
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Arsenic-containing Salts of Some 9-Aminoacridines

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During the 1939–1945 war it was learned that German investigators had found high anti-typhus activity in work on a substance called Rutenol. The earlier reports^{1,2} indicated that the drug was a salt comprised of two moles of 9-(3-diethylamino-2-hydroxypropylamino)-2,3-dimethoxy-6-nitroacridine (I) and three moles of arsenious oxide. Our work was nearly completed when the correct nature of Rutenol was disclosed³ as the salt of one mole of (I) with two moles of 4-glycolylaminophenylarsonic acid. The study was not pursued further, for this salt (Rutenol) has been investigated thoroughly;⁴ this program involved the salts of 9-aminoacridines, in particular, with arsenious oxide.



The reaction of 9-(3-diethylamino-2-hydroxypropylamino)-2,3-dimethoxy-6-nitroacridine dihydrochloride with sodium arsenite produced a substance in which the ratio of base to acid was 3:1. A series of variations gave only the so-called Rutenol or recovered base. The material isolated was a reddish-orange solid, m.p. 197–199° dec. (cor.), soluble in water to 1% w./v.; the aqueous solution (pH 6.25) contained no ionic arsenic. In hope of obtaining information concerning this complex from I, trials were made to obtain related substances from other 9-aminoacridines, including: quinacrine, 6-chloro-9-(3-diethylamino-2-hydroxypropylamino)-2-methoxyacridine ("Acranil"), 6-chloro-9-(4-diethylaminobutylamino)-2-methoxyacridine, 6-chloro-9-(4-dimethylaminoanilino)-2-methoxyacridine and 6-chloro-9-(4-diethylamino-1-methylbutylamino)-

(1) G. Holler, *Med. Klinik*, **40**, 374 (1944).

(2) Office of the Publication Board, Dept. of Commerce, Washington, D. C., 1945: (a) V. Conquest, E. C. Kleiderer, J. B. Rice and J. H. Williams, Report 4, p. 15; (b) H. M. Leaper, J. E. Smadel, L. M. White and E. H. Volwiler, Report 241, p. 5; (c) E. C. Kleiderer, J. B. Rice, V. Conquest and J. H. Williams, Report 981, p. 19.

(3) J. E. Smadel, J. C. Snyder, E. B. Jackson, J. P. Fox and H. L. Hamilton, *J. Immunol.*, **57**, 155 (1947).

(4) M. Bockmühl and A. Fehrle, U. S. Patent 2,040,070.