# PREPARATION AND CHEMISTRY OF $\Delta^8$-HEXAHYDRO-1,4,8-PYRIMIDAZOLE, $\Delta^9$-1,5,9-TRIAZABICYCLO(4.4.0)DECENE, AND $\Delta^9$-1,4,9-TRIAZABICYCLO(5.3.0)DECENE[1]

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ABSTRACT

The preparations of $\Delta^8$-hexahydro-1,4,8-pyrimidazole, $\Delta^9$-1,5,9-triazabicyclo(4.4.0)decene, and $\Delta^9$-1,4,9-triazabicyclo(5.3.0)decene from the corresponding 2-($\omega$-hydroxyalkylamino)-$\Delta^2$-1,3-diazacycloalkenes by chlorination and dehydrohalogenation are described. The nitro derivatives of these bicyclic compounds are more stable towards refluxing ethanol than 1-nitro-2,3,5,6-tetrahydro-1-imidaz(1,2-*a*)imidazole.

The guanidino bicyclic compounds $\Delta^8$-hexahydro-1,4,8-pyrimidazole (III, $n = 3$, $m = 2$), $\Delta^9$-1,5,9-triazabicyclo(4.4.0)decene (III, $n$ and $m = 3$), and $\Delta^9$-1,4,9-triazabicyclo-(5.3.0)decene (III, $n = 4$, $m = 2$) were prepared by the general method which was previously employed in the synthesis of 2,3,5,6-tetrahydro-1-imidaz(1,2-*a*)imidazole (5) and its derivatives (3).

The 2-($\omega$-hydroxyalkylamino)-$\Delta^2$-1,3-diazacycloalkenes (I) were prepared in excellent yields by refluxing the alkanolamines with 2-methylmercapto-$\Delta^2$-1,3-diazacycloalkene salts. This is the same process used by Aspinall and Bianco (1) in the preparation of 2-alkylamino-$\Delta^2$-imidazolinium iodides from amines and 2-methylmercapto-2-imidazolinium iodide. These 2-($\omega$-hydroxyalkylamino)-$\Delta^2$-1,3-diazacycloalkenes (I) on chlorination with thionyl chloride gave the corresponding 2-($\omega$-chloroalkylamino)-$\Delta^2$-1,3-diazacycloalkene hydrochlorides (II) in good yields. The latter compounds on dehydrohalogenation with boiling methanolic potassium hydroxide solution gave the corresponding bicyclic compounds III in yields varying between 25.6% and 69.9%.

The same bicyclic product was obtained from 2-($\beta$-hydroxyethylamino)-$\Delta^2$-tetrahydropyrimidine (I, $n = 3$, $m = 2$) and 2-($\gamma$-hydroxypropylamino)-$\Delta^2$-imidazoline (I, $n = 2$, $m = 3$). Thus the double bond in the final bicyclic guanidino compound must be in the ring with least strain. At present this bicyclic compound has been assigned structure III ($n = 3$, $m = 2$). $\Delta^8$-Hexahydro-1,4,8-pyrimidazole (III, $n = 3$, $m = 2$) on nitration in nitric acid – acetic anhydride medium gives only one nitration product. The nitration product (m.p. 145.5–146° C.) gave analytical values in agreement with those calculated for 1-nitro-$\Delta^8$-hexahydro-1,4,8-pyrimidazole nitrate (IV, $n = 3$, $m = 2$). This nitro compound was recovered unchanged after it had been refluxed in absolute ethanol for $2\frac{1}{2}$ hours. Thus 1-nitro-$\Delta^8$-hexahydro-1,4,8-pyrimidazole nitrate is much more stable than 1-nitro-2,3,5,6-tetrahydro-1-imidaz(1,2-*a*)imidazole nitrate (5). The latter compound on being refluxed in absolute ethanol was converted into 1-($\beta$-nitraminoethyl)-2-imidazolidone.

The symmetrical bicyclic guanidino compound, $\Delta^9$-1,5,9-triazabicyclo(4.4.0)decene (III, $m$ and $n = 3$), was prepared from 2-($\gamma$-hydroxypropylamino)-$\Delta^2$-tetrahydropyrimidine (I, $m$ and $n = 3$). This bicyclic containing the two 6-membered rings formed a carbonate very readily. It was much more difficult to obtain in a pure state and it was identified as its picrate (m.p. 220.5–222° C.). This difficulty with carbonate formation was not encountered with the 5,5-, 5,6-, and 5,7-membered bicyclic guanidino compounds.

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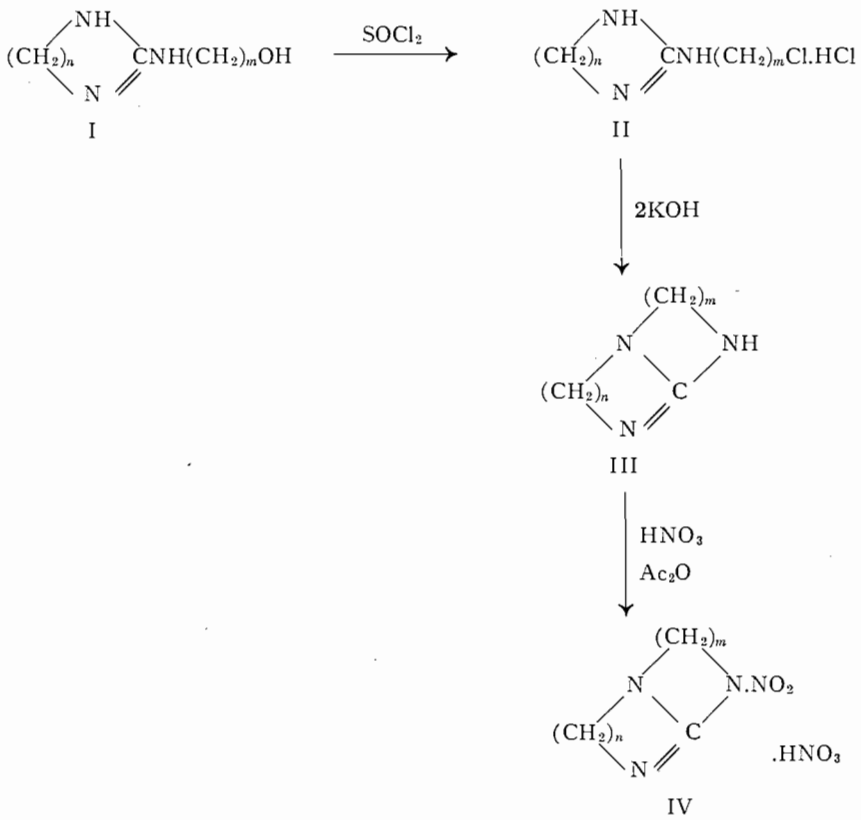


$\Delta^9$-1,5,9-Triazabicyclo(4.4.0)decene on nitration gave a 49% yield of 1-nitro-$\Delta^9$-1,5,9-triazabicyclo(4.4.0)decene nitrate (m.p. 100–101° C.). This nitro derivative IV ($m$ and $n$ = 3) was recovered unchanged after it had been refluxed for 2½ hours in absolute ethanol.

The 5,7-membered bicyclo guanidino compound was obtained from 2-($\beta$-hydroxyethylamino)-$\Delta^2$-1,3-diazacycloheptene (I, $n$ = 4, $m$ = 2) in relatively good yields. This compound could exist as structure III with $n$ = 4 and $m$ = 2 or $n$ = 2 and $m$ = 4. At present the former structure is preferred but it has not been proved. The 5,7-membered bicyclic guanidino compound on nitration gives a mono nitro derivative in quantitative yield which on the basis of structure III ($n$ = 4, $m$ = 2) would be 1-nitro-$\Delta^9$-1,4,9-triazabicyclo-(5.3.0)decene nitrate (IV, $n$ = 4, $m$ = 2).

## EXPERIMENTAL[2]

### *2-Methylmercapto-2-imidazolinium Iodide*

2-Methylmercapto-2-imidazolinium iodide (m.p. 141–143° C.) was prepared in 92% yield by the method of Aspinall and Bianco (1).

### *Hexahydropyrimidine-2-thione*

Hexahydropyrimidine-2-thione (m.p. 212–212.5° C.) was prepared in 67.5% yield as previously described (4).

[2]*All melting points are uncorrected. The microanalyses were determined by Micro Tech Laboratories, Skokie, Illinois.*

*2-Methylmercapto-$\Delta^2$-tetrahydropyrimidinium Iodide*

Methylation of hexahydropyrimidine-2-thione as previously (4) described gave a 96.6% yield of 2-methylmercapto-$\Delta^2$-tetrahydropyrimidinium iodide (m.p. 146–147° C.). One crystallization from ethanol raised the melting point to 149° C.

*1,3-Diazacycloheptane-2-thione*

A stirred solution of 1,4-diaminobutane (88.15 g., 1 mole) in ethanol (200 cc.) was maintained below 20° C. while carbon disulphide (76.13 g., 1 mole) was added over a period of 30 minutes. The precipitate (m.p. 168–171° C.) was removed by filtration and washed with ethanol (100 cc.), yield 158.5 g. (96.5%). The reported (7) melting point of the inner salt of the dithiocarbamate of tetramethylenediamine is 173° C. The inner salt (100 g.) was refluxed in water (500 cc.) for 14 hours, during which time hydrogen sulphide was evolved. This solution on cooling deposited a mixture of crystals and oil. The crystals and oil were separated by extraction with hot water. The aqueous solution on cooling deposited crystals (m.p. 177–179° C.) of 1,3-diazacycloheptane-2-thione, yield 50.5 g. (63.2%). The melting point of tetramethylenethiourea is reported (7) in the literature as 177° C.

*2-Methylmercapto-$\Delta^2$-1,3-diazacycloheptene Hydroiodide*

Tetramethylenethiourea (34.0 g., 0.26 mole) in absolute methanol (100 cc.) was refluxed with methyl iodide (40.3 g., 0.29 mole) for 30 minutes. The solution was cooled and ether (150 cc.) was added. The crystals (m.p. 126.5–128.5° C.) were recovered by filtration, yield 68.0 g. (95.8%). Two crystallizations from methanol–ether solution raised the melting point to 127.5–128.5° C. Anal. Calc. for $C_6H_{13}IN_2S$: C, 26.47; H, 4.81; N, 10.30%. Found: C, 26.70; H, 4.95; N, 10.43%. The picrate formed in the usual manner from water melted at 158–159° C. Anal. Calc. for $C_{12}H_{15}N_5O_7S$: C, 38.61; H, 4.05; N, 18.77; S, 8.59%. Found: C, 38.66; H, 4.23; N, 18.54; S, 8.46%.

*2-($\gamma$-Hydroxypropylamino)-2-imidazolinium Iodide and Chloride*

A solution of 2-methylmercapto-2-imidazolinium iodide (400 g., 1.64 moles) and 3-amino-1-propanol (123 g., 1.64 moles) in absolute ethanol (500 cc.) was refluxed until the evolution of methyl mercaptan had ceased. The oil which remained after removal of the ethanol *in vacuo* crystallized when left standing for 2 days at room temperature, yield 445 g. (100%). The melting point of the crystals was raised from 48–55° C. to 71.5–73° C. by two crystallizations from absolute methanol–ethyl acetate (1:4) solution. Anal. Calc. for $C_6H_{14}IN_3O$: C, 26.58; H, 5.21; N, 15.50; I, 46.81%. Found: C, 26.66; H, 5.07; N, 15.60; I, 46.53%.

2-($\gamma$-Hydroxypropylamino)-2-imidazolinium iodide (435 g., 1.6 moles) in absolute methanol (8700 cc.) was passed through a column of IRA-400 resin[3] at the rate of 12 cc. per minute. The resin was washed with methanol (8 l.) until no further precipitate was obtained with aqueous picric acid solution and then the eluate and washings were evaporated to dryness *in vacuo* under nitrogen. The residual oil was acidified with concentrated hydrochloric acid (140 cc.) and the solution was evaporated to dryness *in vacuo* under nitrogen, yield 294 g. A sample (3 g.) of this light yellow crystalline solid (93–95.5° C.) was crystallized from methanol–ethyl acetate (1:2) solution. The pure product melted at 95–96° C. Anal. Calc. for $C_6H_{14}ClN_3O$: C, 40.12; H, 7.85; N, 23.39; Cl, 19.74%. Found: C, 39.90; H, 7.84; N, 22.91; Cl, 19.90%.

[3]*Exhausted IRA-400 resin (4 l.) was placed in a glass column (diam. 7 cm., height 90 cm.) and it was regenerated with 12 l. of 4% aqueous sodium hydroxide solution. The column of resin was washed with water (6 l.) and absolute methanol (5 l.).*

*2-(γ-Chloropropylamino)-2-imidazolinium Chloride*

Purified thionyl chloride (251.0 g., 2.11 moles) was added over a period of 1 hour at room temperature to a stirred solution of 2-(γ-hydroxypropylamino)-2-imidazolinium chloride (291 g., 1.62 moles) in freshly distilled chloroform (900 cc.). After this reaction had been heated at 40° C. for 1 hour and at 60–65° C. for 3 hours, it was evaporated to dryness *in vacuo* under nitrogen, yield 319.1 g. (99.4%).

A sample (579 mg.) of this semicrystalline viscous oil on treatment with saturated aqueous picric acid solution gave a crystalline picrate (m.p. 160–163° C.), yield 1.02 g. (89.3%). Three crystallizations from water raised the melting point to 166–166.5° C. Anal. Calc. for $C_{12}H_{15}ClN_6O_7$: C, 36.88; H, 3.87; N, 21.52; Cl, 9.08%. Found: C, 37.10; H, 3.95; N, 21.58; Cl, 9.46%.

*2-(β-Hydroxyethylamino)-Δ²-tetrahydropyrimidine Picrate*

2-Methylmercapto-Δ²-tetrahydropyrimidinium iodide (94.5 g., 0.366 mole) and ethanolamine (22.3 g., 0.366 mole) in absolute ethanol (200 cc.) were refluxed for 3½ hours until the evolution of methyl mercaptan had subsided. The solution was evaporated to dryness *in vacuo* under nitrogen. The residue was a slightly yellow crystalline solid, yield 100 g.

The crude 2-(β-hydroxyethylamino)-Δ²-tetrahydropyrimidinium iodide (98.8 g., 0.365 mole) in water (2 l.) was passed through a column of IRA-400 resin (1 l. of resin in the hydroxyl form in a column 5 cm. in diam.) at the rate of 10 cc. per minute. The column was washed with water (6 l.) and the combined eluate and washings were concentrated to 800 cc. This solution was acidified with concentrated hydrochloric acid (28 cc.) and then evaporated to dryness *in vacuo*. The yield was 65.5 g. (100%). A sample of the semicrystalline oil gave a crystalline picrate (m.p. 119–122° C.) on treatment with saturated aqueous picric acid solution. Two crystallizations from ethanol raised the melting point to 129° C. Anal. Calc. for $C_{12}H_{16}N_6O_8$: C, 38.72; H, 4.33; N, 22.59%. Found: C, 38.77; H, 4.33; N, 22.91%.

*2-(β-Chloroethylamino)-Δ²-tetrahydropyrimidinium Chloride*

Purified thionyl chloride (55.9 g., 0.47 mole) was added to a stirred solution of 2-(β-hydroxyethylamino)-Δ²-tetrahydropyrimidinium chloride (65 g., 0.362 mole) in freshly distilled chloroform (200 cc.) at room temperature. After the initial reaction had subsided, the solution was refluxed for 4 hours. The solvent and excess thionyl chloride were removed *in vacuo* to yield 72 g. (100%) of dark brown oil. A sample (571 mg.) of the oil on treatment with a saturated aqueous picric acid solution gave 645 mg. (57.4%) of a crystalline picrate (m.p. 153–156° C.). Two crystallizations from water raised the melting point to 157.5–158° C. Anal. Calc. for $C_{12}H_{15}ClN_6O_7$: C, 36.89; H, 3.87; N, 21.52; Cl, 9.08%. Found: C, 36.69; H, 3.96; N, 21.90; Cl, 8.90%.

*Δ⁸-Hexahydro-1,4,8-pyrimidazole*

*Method A*

A solution of 2-(γ-chloropropylamino)-2-imidazolinium chloride (307 g., 1.55 moles) in absolute methanol (1 l.) was placed in a three-necked flask fitted with a stirrer, condenser, and dropping funnel. The solution was heated to reflux with stirring, and potassium hydroxide (173.9 g., 3.10 moles) in absolute methanol (1865 cc.) was added over a period of 85 minutes. After the reaction mixture had refluxed for a further 4 hours, it was allowed to cool and the precipitated potassium chloride was removed by filtration, yield 208.2 g. (90%). The filtrate was evaporated to dryness *in vacuo* under nitrogen.

The semicrystalline residue was extracted with chloroform (500 cc.) to eliminate residual potassium chloride and the chloroform solution was evaporated *in vacuo* under nitrogen. The crude product on distillation gave 132 g. (69.9%) of pale yellow crystals (b.p. 103–105° C./0.1 mm.). A sample (17.3 g.) of these crystals was crystallized from acetone at −15° C. The pure material melted at 64–65° C., yield 8.1 g. This material combined readily with carbon dioxide from the air and it was hygroscopic. Thus a picrate was prepared for analysis. The picrate prepared in the usual manner from water melted at 228.5–229° C., yield 92%. One crystallization from water raised the melting point to 230° C. Anal. Calc. for $C_{12}H_{14}N_6O_7$: C, 40.67; H, 3.98; N, 23.73%. Found: C, 40.71; H, 4.07; N, 23.63%.

*Method B*

2-(β-Chloroethylamino)-$\Delta^2$-tetrahydropyrimidinium chloride (71 g., 0.359 mole) in absolute methanol (150 cc.) was treated with 2 mole equivalents of potassium hydroxide in methanol under the conditions described above under Method A for the dehydrohalogenation of 2-(γ-chloropropylamino)-2-imidazolinium chloride. The final product was a semicrystalline brown oil, yield 45 g.

A paper chromatogram of the oil developed with butanol – water – acetic acid (4:5:1) solvent on No. 1 Whatman chromatography paper showed two spots with $R_f$ values of 0.54 and 0.24. A sample of $\Delta^8$-hexahydro-1,4,8-pyrimidazole (m.p. 65° C.) from the preparation described above in Method A gave a $R_f$ value of 0.55±0.01 when its paper chromatogram was prepared under identical conditions.

An aqueous solution of oil (247 mg.) gave a crystalline picrate (m.p. 212–224° C.), yield 283 mg. (40.5%). Two crystallizations from water raised the melting point to 228.5–230° C. This picrate did not depress the melting point of $\Delta^8$-hexahydro-1,4,8-pyrimidazole picrate (m.p. 230° C.) prepared from 2-(γ-chloropropylamino)-2-imidazolinium chloride.

A portion (35.5 g.) of the brown oil on distillation *in vacuo* at 0.04 mm. pressure gave 9.86 g. of oil and 3.36 g. of sublimed crystals. The brown tar-like residue was discarded. The oil was redistilled *in vacuo* to give 8.4 g. of colorless oil (b.p. 112–115° C. at 0.3 mm.) which crystallized on cooling to 0° C. The melting point of this material was raised from 58–61° C. to 63–65° C. by one crystallization from acetone. A mixture melting point determination with the crystals (m.p. 64–65° C.) obtained above in Method A showed no depression.

The crystalline sublimate (3.36 g.) from the first distillation sublimed between 241° and 255° C. A sample of the sublimed crystals (40 mg.) in water (1 cc.) was treated with saturated aqueous picric acid solution. The crystalline picrate (m.p. 187–189° C.) was obtained in 81.5% (107 mg.) yield. Two crystallizations from water raised the melting point to 190–191° C. A mixture melting point determination with the picrate (2) of 1,3-diazacyclohexanone-2 showed no depression.

*2-(γ-Hydroxypropylamino)-$\Delta^2$-tetrahydropyrimidinium Iodide and Chloride*

2-(γ-Hydroxypropylamino-$\Delta^2$-tetrahydropyrimidinium iodide was prepared in quantitative yield from 2-methylmercapto-$\Delta^2$-tetrahydropyrimidinium iodide and 3-amino-1-propanol under the conditions described above for the preparation of 2-(γ-hydroxypropylamino)-2-imidazolinium iodide.

A sample (606.6 mg.) of the oil on treatment with a saturated aqueous picric acid solution gave a 47.3% (387 mg.) yield of a crystalline picrate (m.p. 132–137° C.). Two crystallizations from water raised the melting point to 138–139° C. Anal. Calc. for

$C_{13}H_{18}N_6O_8$: C, 40.41; H, 4.69; N, 21.75%. Found: C, 40.30; H, 4.52; N, 22.00%. 2-($\gamma$-Hydroxypropylamino)-$\Delta^2$-tetrahydropyrimidinium chloride was prepared in quantitative yield from the iodide salt by the method described above for the conversion of the iodide salt of 2-($\gamma$-hydroxypropylamino)-2-imidazoline into its hydrochloride.

*2-($\gamma$-Chloropropylamino)-$\Delta^2$-tetrahydropyrimidinium Chloride*

2-($\gamma$-Hydroxypropylamino)-$\Delta^2$-tetrahydropyrimidinium chloride (47.4 g., 0.25 mole) and thionyl chloride (38.0 g., 0.32 mole) in freshly distilled chloroform (150 ml.) were refluxed for $3\frac{1}{2}$ hours. The reaction product was worked up by the method described above in the preparation of 2-($\gamma$-chloropropylamino)-2-imidazolinium chloride to give 51 g. (98%) of a light brown oil.

A sample of this oil in water gave a crystalline picrate (m.p. 147–148.5° C.) in 53.8% yield. Three crystallizations from absolute ethanol raised the melting point to 150–151° C. Anal. Calc. for $C_{13}H_{17}ClN_6O_7$: C, 38.56; H, 4.23; Cl, 8.76; N, 20.76%. Found: C, 38.81; H, 4.44; Cl, 8.65; N, 20.56%.

*$\Delta^9$-1,5,9-Triazabicyclo(4.4.0)decene*

2-($\gamma$-Chloropropylamino)-$\Delta^2$-tetrahydropyrimidinium chloride (52 g., 0.25 mole) was refluxed with two mole equivalents of potassium hydroxide in methanol (300 cc.) for 4 hours. The product was recovered as a semicrystalline solid by the same procedure used above in the preparation of $\Delta^8$-hexahydro-1,4,8-pyrimidazole, yield 39.0 g.

The crude reaction product gave two spots on a paper chromatogram developed with butanol – water – acetic acid (4:5:1) solution. These spots, which were developed with bromocresol green, had $R_f$ values of 0.55±0.01 and 0.24±0.01. When the pure bicyclic compound was isolated, it was found to have an $R_f$ value of 0.55±0.01 under similar conditions while 1,3-diazacyclohexanone-2 had an $R_f$ value of 0.24.

A portion (29.3 g.) of the semicrystalline solid was extracted in a Soxhlet extractor with ethyl acetate (1×600 cc.) and then acetone (7×250 cc.). On cooling these combined solutions deposited 197 mg. of crystals which sublimed at 255° C. These crystals on treatment with aqueous picric acid solution gave a crystalline picrate (m.p. 186–188° C.). One crystallization from water raised the melting point to 190° C. This picrate on admixture with a sample of the picrate of 1,3-diazacyclohexanone-2 (m.p. 191° C.) (2) showed no depression.

The solvent from the extraction on concentration and cooling gave crystals melting at 146–175° C., yield 8.7 g. (25.6%). These crystals could not be purified because they always crystallized as a mixture of free base and its carbonate salt. A sample of the crystals on treatment with a saturated aqueous picric acid solution gave a 90.2% yield of crystalline picrate (m.p. 216–220° C.). Two crystallizations from absolute ethanol raised the melting point to 220.5–222° C. Anal. Calc. for $C_{13}H_{16}N_6O_7$: C, 42.39; H, 4.38; N, 22.82%. Found: C, 42.38; H, 4.52; N, 22.57%.

*2-($\beta$-Hydroxyethylamino)-$\Delta^2$-1,3-diazacycloheptene Hydrochloride*

2-($\beta$-Hydroxyethylamino)-$\Delta^2$-1,3-diazacycloheptene hydroiodide was prepared in quantitative yield from ethanolamine and 2-methylmercapto-$\Delta^2$-1,3-diazacycloheptene hydroiodide by the procedure described (5) for the preparation of 2-($\beta$-hydroxyethylamino)-2-imidazolinium iodide.

2-($\beta$-Hydroxyethylamino)-$\Delta^2$-1,3-diazacycloheptene hydroiodide (129 g., 0.453 mole) in methanol (2.6 l.) was passed through a column of IRA-400 resin (1.4 liters of resin in the hydroxyl form previously washed with methanol (6 l.)) at a rate of 30 cc. per

minute. After the column was washed with methanol (5 l.), the combined eluates (7.6 l.) were concentrated to a volume of 400 cc. under nitrogen at reduced pressure. A sample of this solution on treatment with a saturated aqueous solution of picric acid gave a crystalline picrate (m.p. 103° C.). Anal. Calc. for $C_{13}H_{18}N_6O_8$: C, 40.41; H, 4.70; N, 21.76%. Found: C, 40.37; H, 4.59; N, 21.90%. The methanolic solution of free base was acidified with concentrated hydrochloric acid solution (43 cc.) and then evaporated to dryness *in vacuo*.

*2-(β-Chloroethylamino)-Δ²-1,3-diazacycloheptene Hydrochloride*

A mixture of 2-(β-hydroxyethylamino)-Δ²-1,3-diazacycloheptene hydrochloride (87 g., 0.453 mole) and purified thionyl chloride (71 g., 0.6 mole) in freshly distilled chloroform (250 cc.) was refluxed for $3\frac{1}{2}$ hours. The solvent and excess thionyl chloride were removed *in vacuo*. A reddish-brown colored oil remained, yield 95.5 g. (100%). A sample (280 mg.) of this oil in water (2 cc.) on treatment with a saturated aqueous picric acid solution gave 385 mg. (72%) of a crystalline picrate (m.p. 121–122° C.). Two crystallizations from methanol–water solution raised the melting point to 122.5–123° C. Anal. Calc. for $C_{13}H_{17}ClN_6O_7$: C, 38.56; H, 4.23; Cl, 8.76; N, 20.76%. Found: C, 38.62; H, 4.43; Cl, 8.97; N, 21.03%.

*Δ⁹-1,4,9-Triazabicyclo(5.3.0)decene*

2-(β-Chloroethylamino)-Δ²-1,3-diazacycloheptene hydrochloride (95.5 g., 0.45 mole) was dehydrohalogenated by the same procedure used in the preparation of 2,3,5,6-tetrahydro-1-imidaz(1,2-*a*)imidazole (5). A pale yellow crystalline solid containing some potassium chloride was obtained, yield 67.7 g.

A paper chromatogram of the oil on No. 1 Whatman chromatography paper using butanol – acetic acid – water (4 : 1 : 5) solvent showed one spot with an $R_f$ value of 0.60 ± 0.02. The spot was developed with bromocresol green indicator. The crude material (502 mg.) in water gave a crystalline picrate (m.p. 211–213° C.), yield 1.18 g. (89.7%). One crystallization from absolute methanol raised the melting point to 216–218° C. Anal. Calc. for $C_{13}H_{16}N_6O_7$: C, 42.39; H, 4.38; N, 22.82%. Found: C, 42.23; H, 4.55; N, 22.51%.

The crude product was crystallized from acetone (250 cc.) to give 27 g. of crystalline product melting at 107–111° C. After the mother liquors were concentrated to 150 cc. a second crop (6 g.) of crystals (m.p. 106–111° C.) was obtained. The mother liquors from the second crop on evaporation *in vacuo* under nitrogen gave an oil which was distilled. A colorless oil (b.p. 118–122° C. at 0.26 mm.) was obtained and it crystallized almost immediately, yield 6.5 g. The total yield of Δ⁹-1,4,9-triazabicyclo(5.3.0)decene was 39.5 g. (63.1%). A sample (1.1 g.) of these crystals (m.p. 107–111° C.) was purified for analysis by crystallization from acetone. The final melting point was 109–111° C. Anal. Calc. for $C_7H_{13}N_3$: C, 60.40; H, 9.41; N, 30.19%. Found: C, 60.24; H, 9.37; N, 29.81%.

*1-Nitro-Δ⁹-1,5,9-triazabicyclo(4.4.0)decene Nitrate*

Δ⁹-1,5,9-Triazabicyclo(4.4.0)decene (1.5 g., 0.010 mole) was added over a period of 20 minutes to a solution of absolute nitric acid (4.98 cc., 0.11 mole) in acetic anhydride (10.2 cc., 0.10 mole) at 0° C. The temperature was allowed to rise to 32° C. over a period of 5 minutes and it was held at this temperature for 20 minutes. This solution was poured into 150 cc. of cold ether. The ether supernatant was decanted from the oil and the oil was washed with ether several times by decantation, the oil was dissolved in absolute

ethanol (10 cc.) at room temperature and ether (10 cc.) was added. After the solution had remained in the refrigerator for 2 hours, the crystals (m.p. 98–101° C.) were removed by filtration, yield 1.31 g. (49.1%). One crystallization from ethanol–ether raised the melting point to 100–101° C. Anal. Calc. for $C_7H_{13}N_5O_5$: C, 34.00; H, 5.30; N, 28.33%. Found: C, 34.01; H, 5.46; N, 28.16%.

A picrate (m.p. 143.5–144.5° C.) of this compound was prepared in 63% yield in water in the usual manner. Two crystallizations from water raised the melting point to 144–144.5° C. Anal. Calc. for $C_{13}H_{15}N_7O_9$: C, 37.78; H, 3.66; N, 23.73%. Found: C, 38.17; H, 3.73; N, 24.03%.

1-Nitro-$\Delta^9$-1,5,9-triazabicyclo(4.4.0)decene nitrate (297.6 mg.) in absolute ethanol (20 cc.) was refluxed for $2\frac{1}{2}$ hours. After the ethanol was removed *in vacuo* under nitrogen, crystals (m.p. 99–101° C.) were obtained, yield 272 mg. (91.6%). These crystals on admixture with the starting material did not depress the melting point.

*Nitration of $\Delta^8$-Hexahydro-1,4,8-pyrimidazole*

$\Delta^8$-Hexahydro-1,4,8-pyrimidazole (3.75 g., 0.03 mole) was nitrated in nitric acid–acetic anhydride medium and isolated under conditions similar to those described above in the preparation of 1-nitro-$\Delta^9$-1,5,9-triazabicyclo(4.4.0)decene nitrate.

The oily product crystallized on drying *in vacuo* over phosphorus pentoxide, yield 3.24 g. (46.3%). The melting point was raised from 143.5–145.5° C. to 145.5–146° C. by one crystallization from ethanol. Anal. Calc. for $C_6H_{11}N_5O_5$: C, 30.90; H, 4.76; N, 30.0%. Found: C, 31.15; H, 4.86; N, 29.94%. 1-Nitro-$\Delta^8$-hexahydro-1,4,8-pyrimidazole nitrate (m.p. 145–146° C.) was recovered unchanged after it had been refluxed in ethanol solution for $2\frac{1}{2}$ hours.

*Nitration of $\Delta^9$-1,4,9-Triazabicyclo(5.3.0)decene*

$\Delta^9$-1,4,9-Triazabicyclo(5.3.0)decene (1.39 g., 0.01 mole) was nitrated in nitric acid–acetic anhydride medium under the conditions described above for the nitration of $\Delta^9$-1,5,9-triazabicyclo(4.4.0)decene. When the reaction mixture was poured into cold ether, crystals (m.p. 163–165° C.) separated immediately. The yield was quantitative. Three crystallizations from ethanol–ether solution raised the melting point to 166.5–167.5° C. Anal. Calc. for $C_7H_{13}N_5O_5$: C, 34.00; H, 5.30; N, 28.33%. Found: C, 33.99; H, 5.32; N, 27.76%.

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