Further work is in progress on the stereochemistry of the deoxystreptamine and neosamine B fragments.

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## THE PREPARATION OF A NEW BORON HYDRIDE $B_{18}H_{22}$

*Sir:*

We wish to report the synthesis of a new boron hydride which probably contains more boron atoms per molecule than any boron hydride yet isolated in quantity. At the present time we prefer the formulation $B_{18}H_{22}$ for this hydride although the difficulty in obtaining precise hydrogen analyses in a molecule of this size makes the hydrogen content questionable. A complete structural analysis is currently underway in the laboratory of Prof. William N. Lipscomb.

The oxidation of the $B_{10}H_{10}^{-2}$ ion[1-5] with aqueous ferric chloride has been reported[6] to produce an ion, $B_{20}H_{18}^{-2}$ (m.p. triethylammonium salt, 173–174°, I). An ethanolic solution of I was passed through an acidic ion exchange resin and the resulting solution was concentrated to a yellow syrup at steam bath temperature in the air or under reduced pressure in a vacuum system. The addition of water to a diethyl ether solution of the concentrate results in rapid hydrolysis accompanied by the evolution of hydrogen. The hydride was obtained by evaporation of the solvent followed by recrystallization from cyclohexane and sublimation. Yields of up to 60% have been obtained. Preliminary work indicates that a least one other new hydride is also produced. The purified hydride is stable in the air and melts at 177–178.5° without decomposition. *Anal.* Calcd. for $B_{18}H_{22}$: B, 89.95; H, 10.15. Found. B, 89.11; H, 10.44. A more precise analysis for hydrogen was carried out by the thermal decomposition of a weighed sample to the elements at 900°[7] (mole $H_2$ calcd. for $B_{18}H_{22}$, $2.18 \times 10^{-3}$. Found. $2.21 \times 10^{-3}$). Ebullioscopic molecular weights averaged 212.7 (calcd., 216.8). Titration with aqueous hydroxide ion revealed that the presumed $B_{18}H_{22}$ was a strong monoprotic acid (equiv. wt. 219.5). Unit cell dimensions and an accurate density determination[8] fixes the molecular weight at 216 ± 1. This value confirms the $B_{18}$ formulation. The derived anion is bright yellow in color and has been separated as the triethylammonium and tetramethylammonium salts.

The infrared spectrum of the hydride exhibits an intense terminal B–H stretching band at 2850 cm.$^{-1}$ and shows B–H–B bridge absorption at 1950 cm.$^{-1}$. Extremely complex skeletal absorptions are present at longer wave lengths, a fact which suggests low symmetry in the hydride. Solutions of the hydride in hydrocarbon solvents exhibit a purple fluorescence. Three ultraviolet absorptions are observed: $(\lambda_{max}^{m\mu})_1/\epsilon_{max})$ 332/6,560; 273.5/3,560 and 217/15,900. The anion derived from the hydride has two major absorption bands in the ultraviolet: 352/5,950 and 216/11,600.

The $B^{11}$ nuclear magnetic resonance spectrum of the hydride is complex and has not been resolved. Further work is in progress.

**Acknowledgment.**—The authors are indebted to Prof. William N. Lipscomb for information regarding the $B_{20}H_{18}^{-2}$ ion received prior to publication and the X-ray molecular weight value reported herein. This investigation was supported by Army Ordnance Contract No. DA-01-021-ORD-11878 with the Rohm and Haas Company.

(8) Private communication of results obtained by P. G. Simpson, R. Lewin and W. N. Lipscomb.

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## CHEMISTRY OF THE NEOMYCINS. X.[1] NEOMYCINS B AND C

*Sir:*

Structures of the fragments of neomycins B and C—the unitary deoxystreptamine,[1,2,3] neosamine C,[4,5] neosamine B (incomplete stereochemistry),[6] and D-ribose[7]; the binary neamine[1] and neobiosamine B[6,8]—have been established in earlier investigations, and the stereochemistry of neosamine

(1) M. F. Hawthorne and A. R. Pitochelli, *J. Am. Chem. Soc.*, **81**, 5519 (1959).

(2) W. N. Lipscomb, A. R. Pitochelli and M. F. Hawthorne, *ibid.*, **81**, 5833 (1959).

(3) W. N. Lipscomb, *Proc. Nat. Acad. Sci.*, **47**, 1791 (1961).

(4) W. H. Knoth, H. C. Miller, D. C. England, G. W. Parshall and E. L. Muetterties, *J. Am. Chem. Soc.*, **84**, 1056 (1962).

(5) A. R. Pitochelli, R. Ettinger, J. A. Dupont and M. F. Hawthorne, *ibid.*, **84**, 1057 (1962).

(6) A. Kaczmarczyk, R. D. Dobrott and W. N. Lipscomb, *Proc. Nat. Acad. Sci.*, paper in press which confirms the structure proposed for the $B_{10}H_{10}^{-2}$ ion in reference (2). See also Communication to the Editor, A. R. Pitochelli, W. N. Lipscomb and M. F. Hawthorne, *J. Am. Chem. Soc.*, **84**, 3026 (1962).

(7) J. Graff and D. Rittenberg, *Anal. Chem.*, **24**, 878 (1952).

(1) Paper IX: H. E. Carter, J. R. Dyer, P. D. Shaw, K. L. Rinehart, Jr., and M. Hichens, *J. Am. Chem. Soc.*, **83**, 3723 (1961).

(2) A. Kuehl, M. N. Bishop and K. Folkers, *ibid.*, **73**, 881 (1951).

(3) Professor R. U. Lemieux (personal communication) recently has confirmed by n.m.r. studies the all-*trans* stereochemistry[1] of deoxystreptamine.

(4) K. L. Rinehart, Jr., and P. W. K. Woo, *J. Am. Chem. Soc.*, **80**, 6463 (1958).

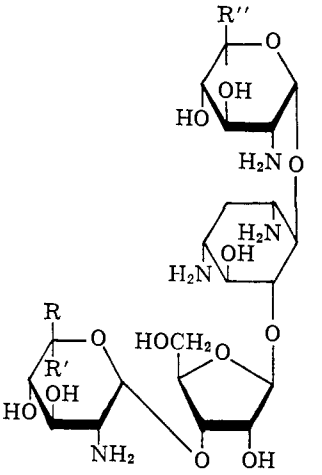
(5) K. L. Rinehart, Jr., M. Hichens, K. Striegler, K. R. Rover, T. P. Culbertson, S. Tatsuoka, S. Horii, T. Yamaguchi, H. Hitomi and A. Miyake, *ibid.*, **83**, 2964 (1961).

(6) K. L. Rinehart, Jr., A. D. Argoudelis, T. P. Culbertson, W. S. Chilton and K. Striegler, *ibid.*, **82**, 2970 (1960).

(7) K. L. Rinehart, Jr., P. W. K. Woo and A. D. Argoudelis, *ibid.*, **79** 4568 (1957).

(8) Earlier[4] the linkage between neosamine C and D-ribose was assigned to the C-2 carbon atom of ribose, from the 2-mole periodate uptake of methyl N,N,-dibenzoylneobiosaminide C. As is demonstrated in the present communication, the C-2 assignment was in error, for reasons not yet clear; it will be discussed in the full paper.

B has been suggested.[9] In the present report the remaining structural points are determined, *i.e.*, the position of attachment of neosamine C to ribose, the stereochemistry of the neosamine B-ribose bond, and the position, ring form, and stereochemistry of the linkage of ribose to neamine. From these results neomycins B and C are assigned structures I and II, respectively.



I (neomycin B) R = H, R′ = $CH_2NH_2$, R″ = $CH_2NH_2$ } suggested stereochemistry

II (neomycin C) R = R″ = $CH_2NH_2$, R′ = H

PI (paromomycin) R = H, R′ = $CH_2NH_2$, R″ = $CH_2OH$ } suggested stereochemistry

PII (suggested for paromomycin II) R = $CH_2NH_2$, R′ = H, R″ = $CH_2OH$

Hydrolysis of periodate-treated hexa-N-acetylneomycin B afforded deoxystreptamine in 80% yield, indicating that neobiosamine B is attached to neamine *via* a hydroxyl group of deoxystreptamine rather than of neosamine C; attachment at C-5 was shown by the isolation of an optically active mono-O-methyldeoxystreptamine from the hydrolysate of poly-O-methyl-hexa-N-acetylneomycin B.

Similar evidence established the linkage of neobiosamine C to C-5 of deoxystreptamine.

Hexa-N-acetylneomycin B was treated with methyl iodide–barium oxide in dimethylformamide,[12] then with silver oxide in methyl iodide, to give the chromatographically homogeneous poly-O-methyl-hexa-N-acetylneomycin B [*Anal.* Calcd. for $C_{23}H_{33}N_6O_6(COCH_3)_6^-$ $(OCH_3)_7$: $CH_3O$, 24.2. Found: $CH_3O$, 19.8, 20.6].[13,14] Hydrolysis (1 *N* hydrochloric acid, steam bath, 3 hours) of 770 mg. of the methylated material gave, after ion exchange, then cellulose chromatography, 9 mg. of 2-O-methyl-D-ribose (from a small amount of incompletely methylated N-acetylneomycin) and 43 mg. of 2,5-di-O-methyl-D-ribose. Similarly, poly-O-methyl-hexa-N-acetylneomycin C (obtained from methylation with methyl iodide and silver oxide in acetone) was hydrolyzed to give 2-O-methyl- and 2,5-di-O-methyl-D-riboses. The methylated riboses were identified by paper chromatography and borate buffer electrophoresis through comparison with samples prepared by an authentic route.[15] Their isolation confirms the previously reported[6] attachment of neosamine B to the C-3 position of ribose, assigns the linkage of neosamine C to the ribose C-3 hydroxyl,[8,16] and establishes the furanose form for ribose in neomycins B and C (though after neomycin methanolysis, it exists in the pyranose form in methyl neobiosaminide B).[6]

Another product obtained from hydrolysis (6 *N* hydrochloric acid, reflux, 2 hours) of poly-O-methyl-hexa-N-acetylneomycins B and C is N,N′-diacetyl-6-O-methyldeoxystreptamine, $[\alpha]^{23}D + 12°$ (*c* 1.0, water), a compound obtained earlier from hydrolysis of poly-O-methylpenta-N-acetylparomomycin.[17,18,20,21]

(9) K. L. Rinehart, Jr., and A. D. Argoudelis, *interalia*, (a) Abstracts of the 17th National Organic Symposium, Bloomington, Indiana, June 25–29, 1961, p. 96; and (b) Abstracts of the 1st Interscience Conference on Antimicrobial Agents and Chemotherapy, New York, Oct. 31–Nov. 2, 1961, p. 268. The argument suggesting L-idose stereochemistry may be summarized briefly: (1) the stereochemistry at C-2 was reported earlier.[9] (2) Isolation of corresponding dinitrophenyl products of opposite rotation (strongly positive and strongly negative) from 6-amino-6-deoxy-D-glucose[10] and methyl neobiosaminide B[11], respectively, by periodate oxidation, followed by N-dinitrophenylation and hydrolysis, assigns the L-configuration to C-5. (3) Lack of periodate uptake of the N,N′-dinitrophenyl derivatives[11] of neosamine B and methyl neobiosaminide B assigns to the C-3 and C-4 hydroxyls a *trans* geometry. (d) The close biosynthetic relationship of neosamine B and neosamine C (M. Hichens and J. L. Foght, unpublished results) favors the stereochemistry of L-idose, which differs from D-glucose only by inversion at C-5, over that of L-mannose, which is inverted at C-3, C-4, and C-5.

(10) We are indebted to Professor R. U. Lemieux for this sample.

(11) K. L. Rinehart, Jr., A. D. Argoudelis, W. A. Goss, A. Sohler and C. P. Schaffner, *J. Am. Chem. Soc.*, **82**, 3938 (1960).

(12) R. Kuhn, H. H. Baer and A. Seeliger, *Ann.*, **611**, 236 (1958).

(13) The n.m.r. spectrum of similarly treated tetra-N-acetyleneamine showed that no N-methylation occurred. We have now achieved virtually complete O-methylation of N-acetylneomycin and N-acetylneamine in a single treatment with methyl iodide, barium oxide and barium hydroxide in dimethylformamide according to a more recent procedure described by Kuhn.[14]

(14) R. Kuhn, H. Egge, R. Brossmer, A. Gauhe, P. Klesse, W. Lochinger, E. Rohm, H. Trischmann and D. Tschampel, *Angew. Chem.*, **72**, 805 (1960).

(15) G. R. Barker, T. M. Noone, D. C. Smith and J. W. Spoors, *J. Chem. Soc.*, 1327 (1955).

(16) A C-3 ribose linkage also may be assigned to neobiosamine C from more recent periodate data. Methyl neobiosaminide C base consumes two moles of periodate rapidly, at a rate essentially equal to that of methyl neobiosaminide B; ribose may be isolated from both these oxidations, even after 89 hours and well over 2 moles of periodate uptake. Moreover, the periodate oxidation of neobiosaminol C yields 1.62 moles of formaldehyde, a value close to the 1.59 moles found during oxidation of neobiosaminol B.

(17) T. H. Haskell, J. C. French and Q. R. Bartz, *J. Am. Chem. Soc.*, **81**, 3483 (1959).

(18) Although deoxystreptamine itself is optically inactive, substitution in the 1-, 3-, 4- or 6-position introduces asymmetry. The absolute stereochemistry of deoxystreptamine in neamine is unknown, but is the same as that in paromamine[19a] (pseudoneamine),[19b,20] and opposite to that in the isolated O-methyldeoxystreptamine. Introducing a convention for the numbering of the atoms of deoxystreptamine, we suggest that the mono-O-methyl derivative of positive rotation described above be named 6-O-methyldeoxystreptamine, so that neamine and pseudoneamine would be described as 4-O-substituted derivatives.[1]

(19) (a) T. H. Haskell, J. C. French and Q. R. Bartz, *J. Am. Chem. Soc.*, **81**, 3480 (1959). (b) G. Hagemann, G. Nomine, and L. Penasse, *Ann. Pharm. Franc.*, **16**, 585 (1958).

(20) The identity of paromomycin with catenulin, hydroxymycin and amminosidin has been reported recently (R. T. Schillings and C. P. Schaffner, Abstracts of the 1st Interscience Conference on Antimicrobial Agents and Chemotherapy, New York, Oct. 31–Nov. 2, 1961, p. 274).

(21) In connection with the present work we have recently isolated a minor component, paromomycin II (PII) from a commercial sample of paramomycin ("Humatin"), hydrolyzable to pseudoneamine and a

The present results complete the gross structures of neomycins B (I) and C (II). The stereochemistry of the glycosidic linkages is discussed in the accompanying communication.

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disaccharide closely resembling neobiosamine C. Strong acid hydrolysis of the disaccharide affords neosamine C, characterized as the crystalline N,N′-diacetyl derivative. The principal diaminohexose of paromomycin (PI), paromose, forms a crystalline N,N′-diacetyldihydro derivative,[22] which we find to be identical with that obtained from neosamine B. It has been reported that the *p*-nitrophenylhydrazones of the N,N′-diacetyl derivatives of paromose[22] and of neosamine B[23] (diaminohexose I from zygomycin[23]) differ markedly in rotation ($[\alpha]_D$ +6°, $[\alpha]_D$ +162°), but by separate authors neither describing the method of preparation, or crystallization. Since the phenylhydrazones of hexoses are well known to exist in several modifications, and to exhibit complex and often very slow mutarotations,[24] this anomaly appears to be merely unfortunate. However, we are presently reinvestigating these derivatives. These observations point strongly to the great similarity, if not identity, of the zygomycin A complex,[23] and the two-component paromomycin.

(22) T. H. Haskell, J. C. French and Q. R. Bartz, *J. Am. Chem. Soc.*, **81**, 3481 (1959).

(23) (a) S. Horii, T. Yamaguchi, H. Hitomi, and A. Miyake, *Chem. Pharm. Bull. Japan*, **9**, 541 (1961); (b) S. Horii, *J. Antibiotics (Japan)*, ser. A, XIV, 249 (1961).

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(25) National Science Foundation Predoctoral Fellow.

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## THE E.P.R. OF GROUND STATE TRIPLET NITRENES[1]

*Sir:*

Recently electron paramagnetic resonance (e.p.r.) has been observed for transitions between neighboring sublevels of randomly oriented triplet species in rigid glasses.[2] This technique also has been employed to detect diphenylmethylene, a ground state triplet.[3] Since monovalent nitrogen is isoelectronic with divalent carbon, we have investigated the e.p.r. of several nitrenes.

Thermolysis[4] and photolysis[5] of organic azides generally leads to the formation of primary or secondary amines and azo compounds. These products have been interpreted as arising from a nitrene intermediate which reacts as a radical.[4,5] Kinetic evidence obtained from a study of the thermal decomposition of aromatic and aliphatic azides[6] supports this assumed radical nature of the nitrene, as does a study of the orientation and relative rate factors of the products resulting from the decomposition of benzenesulfonyl azide in substituted benzenes.[7]

The experimental procedure was essentially that used previously.[2,3] A dilute solution of the azide in Fluorolube[3] at 77°K. was irradiated with a mercury arc and the resonance absorption recorded with a Varian 100 kc. field modulation e.p.r. spectrometer.[8] Eight azides were investigated: phenyl (I),[4c] *o*-trifluoromethylphenyl (II),[4d] benzenesulfonyl (III),[9] *p*-toluenesulfonyl (IV),[10] cyclohexyl (V),[6] styryl (VI),[4c] ethyl azidoformate (VII)[11] and phenylazidoformate (VIII).[12] No resonance was observed with V to VIII. These negative results can be rationalized by noting that in each case any nitrenes formed can undergo further reaction by processes less likely to occur with compounds I to IV.

With I, II, III, and IV e.p.r. was detected and the intensity of the signal from I was stable at 77°K. for at least eighteen hours after irradiation was discontinued. On warming the signals disappeared. These findings are indicative of a ground state triplet. For I and II there was one line each near 1620 gauss and one at high-field, 6701 and 6713 gauss, respectively. The low field line corresponds to the $\Delta m = 2$ (half-field) transition,[13] the high field lines to $\Delta m = 1$ transitions. No other resonances were observed below 10,000 gauss. Most probably there are additional absorptions at higher fields but the limitations of our magnet precluded their investigation. The over-all width of the resonance is determined by hyperfine interactions[2] and is found to be greater for II (180 gauss) than for I (130 gauss); this is due to the interaction of the unpaired spin with the nearby fluorine atoms in II. With III and IV, a broad (over 300 and 350 gauss) line was seen at 7795 and 7740 gauss, respectively. No half-field transition was found.

Assignment of the zero-field parameters, $D$ and $E$,[14] which give the interaction of the unpaired spins, requires the measurement of additional resonances. However, if we assume that there are no unobserved weak lines below 10,000 gauss, some crude estimates can be made. A possible assignment for I or II would be $D = 1.67$ and $E = 0.27$ cm.$^{-1}$; another is $D = 1.33$ and $E = 0.30$ cm.$^{-1}$.[15,16] These values are considerably

(1) We agree with Lwowski and Mattingly[5b] that "nitrene" is a more suitable term for monovalent nitrogen compounds than "azene" or "imine."

(2) W. A. Yager, E. Wasserman and R. M. R. Cramer, *J. Chem. Phys.*, to be published.

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(5a) D. H. R. Barton, L. R. Morgan, Jr., *J. Chem. Soc.*, 622 (1962); (b) W. Lwowski and T. W. Mattingly, *Tetrahedron Letters*, 277 (1962).

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(8) We wish to thank R. M. R. Cramer for measuring the spectra.

(9) O. C. Dermer and M. T. Edmison, *J. Am. Chem. Soc.*, **77**, 70 (1955).

(10) W. von E. Doering and C. H. DePuy, *ibid.*, **75**, 5955 (1953).

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(13) J. H. van der Waals and M. S. de Groot, *Mol. Phys.*, **2**, 333 (1959), *ibid.*, **3**, 190 (1960).

(14a) K. W. H. Stevens, *Proc. Roy. Soc.* (London), **A214**, 237 (1952); (b) C. A. Hutchison, Jr., and B. W. Mangum, *J. Chem. Phys.*, **34**, 908 (1961).

(15) These values will give only one $\Delta m = 1$ transition below 10,000 gauss and that at 6700 gauss.[14]