New Boron-Nitrogen Analogues of Uracil Derivatives [1]

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Z. Naturforsch. **44b**, 1421–1426 (1989); received May 10, 1989

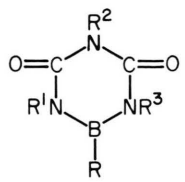
Boron-Nitrogen Compounds, Isoelectronic Species, Azaborauracils, 1,3,5-Triaza-2-boracyclohexa-4,6-diones

The reaction of N,N′-dimethylurea with 1,5-dimethyl-2,4-bis-(dimethylamino)-1,5-diaza-2,4-dibora-3-oxacyclohexan-6-one (**2**) in the melt proceeds with condensation of the urea to yield two major products: the acid 1,3,5-trimethyl-2-hydroxy-1,3,5-triaza-2-boracyclohexa-4,5-dione (**1a**); and a mixture of the methylammonium (**4a**) and dimethylammonium salt (**4b**) of the anion $[\{CH_3N(\mu\text{-}CONCH_3)_2\}_2B]^-$. Analogous products were obtained from the reaction of **2** with N,N′,N″-triorganylbiurets. The 2-hydroxy derivatives of type **1** form 1:1 molar adducts with amines (**3**) of variable thermal stability. The anhydride of **1a** was obtained as the bis(dimethylamine) adduct $[CH_3N(\mu\text{-}CONCH_3)_2B]_2O \cdot 2(CH_3)_2NH$ (**6**) from the reaction of $[(CH_3)_2N]_2BOB[N(CH_3)_2]_2$ with N,N′,N″-trimethylbiuret.

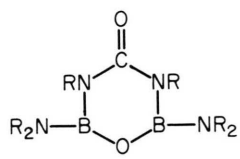
Introduction

The CC and BN moieties are a classical example of a pair of isoelectronic and isosteric species [2]. Although the physical properties of many boron-nitrogen and isosteric organic compounds, *e.g.*, borazine, $(-BH-NH-)_3$, and benzene, are very similar, the chemical behaviour is usually greatly influenced by the differences in the polarities of the isosteric units. On the other hand, the chemical properties of an organic species may be altered to a small extent only by the selective incorporation of a single BN unit into an organic framework, as has been documented for iminoboranes of the type RB≡NR′ and acetylenes [3]. Nevertheless, the physiological and pharmacological properties of such isoelectronic species may still differ considerably. This has prompted an interest in boron-nitrogen analogues of biologically active materials, *e.g.*, boron analogues of amino acids and derivatives thereof have been studies extensively [4].

Uracil is an important constituent of many nucleic acids, but very few boron-nitrogen analogues of uracil derivatives, *i.e.*, 1,3,5-triaza-2-boracyclohexa-4,6-diones containing the principal framework **1,** are known. The limited literature on such species has been summarized earlier [5] and only three relevant studies have appeared since [6–8].



1



2

a: R = OH, $R^1 = R^2 = R^3 = CH_3$ R = CH_3
b: R = OH, $R^1 = R^2 = CH_3$, $R^3 = C_2H_5$
c: R = OH, $R^1 = R^2 = CH_3$, $R^3 = C_6H_5$

Within the course of a general study of the synthesis of boron heterocycles and their interaction with nitrogen donor molecules, reactions of N,N′-dimethylurea with some simple boron-nitrogen derivatives have recently been investigated [8]. In a continuation of this latter work, the reaction of 1,5-dimethyl-2,4-bis(dimethylamino)-1,5-diaza-2,4-dibora-3-oxacyclohexan-6-one (**2**) with N,N′-dimethylurea as well as N,N′,N″-triorganylbiurets has been found to give access to the azaborauracil derivatives **1a–c.** Relevant results are described here.

Results and Discussion

No reaction was observed when 1,5-dimethyl-2,4-bis(dimethylamino)-1,5-diaza-2,4-dibora-3-oxacyclohexan-6-one (**2**) was treated with N,N′-dimethylurea in refluxing toluene. However, when **2** was reacted with excess molten N,N′-dimethylurea at 190–200 °C, two major types of boron-containing products were obtained. Approximately one half of

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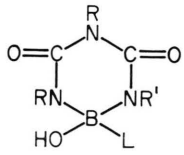
Verlag der Zeitschrift für Naturforschung, D-7400 Tübingen
0932–0776/89/1100–1421/$ 01.00/0

the boron content of the originating **2** was found as the Lewis acid 1,3,5-trimethyl-2-hydroxy-1,3,5-triaza-2-boracyclohexa-4,6-dione (**1a**); and a mixture of the salts **5a** and **5b** was the other major boron-containing product (see below).

The acid **1a** is a thermally stable material that melts and can be sublimed under vacuum without condensation. It is a Lewis acid and adducts of type **3** could be obtained from the interaction of **1b** with methylamine (**3a**) or with dimethylamine (**3b**).

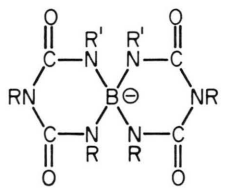


3

a: R = R^1 = CH_3, L = CH_3NH_2
b: R = R^1 = CH_3, L = $(CH_3)_2NH$
c: R = CH_3, R^1 = C_6H_5, L = CH_3NH_2

With triethylamine, however, only weak complexation was observed in solution as indicated by a ^{11}B NMR signal at δ = 2.2, and most of **1b** remained in free state; the acid **1b** was recovered quantitatively after solvent evaporation and drying of the remaining solid under vacuum at ambient temperature. These observations imply that steric factors control the thermal stability of adducts of type **3.**

As noted above, the remainder of the boron of the starting material **2** from its interaction with N,N′-dimethylurea was found as a mixture of the methylammonium (**4a**) and dimethylammonium salt (**4b**) of the anion $[\{CH_3N(\mu\text{-}CONCH_3)_2\}_2B]^-$.

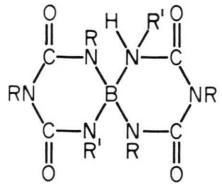


4

a: R = R^1 = CH_3; cation: $[CH_3NH_3]^+$
b: R = R^1 = CH_3; cation: $[(CH_3)_2NH_2]^+$
c: R = R^1 = CH_3; cation: $[(CH_3)_3NH]^+$
d: R = CH_3, R^1 = C_2H_5; cation: $[CH_3NH_3]^+$
e: R = CH_3, R^1 = C_2H_5; cation $[(CH_3)_2NH_2]^+$
f: R = CH_3, R^1 = C_6H_5; cation: $[CH_3NH_3]^+$
g: R = CH_3, R^1 = C_6H_5; cation: $[(CH_3)_2NH_2]^+$

The formation of these salts presents one of the relatively rare cases where a B–O bond is being broken in favor of a B–N bond formation.

On heating of the salts **4a–c** under vacuum, the betaine **5a** was obtained.



5

a: R = R^1 = CH_3
b: R = CH_3, R^1 = C_2H_5
c: R = CH_3, R^1 = C_6H_6

However, the thermal decomposition proceed readily (at 165 °C/10^{-3} Torr) only in the case of **4c.** The salt **4a** showed some decomposition at the melting point, but required much more forcing conditions (300 °C/10^{-3} Torr) than **4c** in order to obtain **5a** (which was extracted from the thermolysis product with chloroform), and the process was accompanied by the formation of unidentified by-products. The same holds true for the thermolysis of **4b.**

The betaine **5a** interacted, in turn, with primary, secondary, or tertiary amines to give salts of type **4.** (The salts **4b** and **4c** (only impure) of the spiroboron anion as well as **5a** have previously been obtained from the interaction of N,N′,N″-trimethylbiuret with tris(dimethylamino)borane or trimethylamineborane, respectively [5].)

In summary, the interaction of **2** with N,N′-dimethylurea in the melt can be described by eq. (1).

$$\mathbf{2} + 5\ OC(NHCH_3)_2 \rightarrow \mathbf{1a} + \mathbf{4a} + 2\ (CH_3)_2NH + 2\ CH_3NH_2 \qquad (1)$$

However, some of the generated dimethylamine can take the place of methylamine in **4a** leading to the observed formation of **4b.** In addition, a noticeable amount of the dimethylamine also interacted with the N,N′-dimethylurea to form N,N,N′-trimethylurea. This corresponds to an earlier observation that on heating of dimethylaminoboranes, $(CH_3)_2NBR_2$, with N,N′-dimethylurea an amino group exchange occurs with the formation of the cor-

responding monomethylaminoboranes and N,N,N′-trimethylurea [9].

As noted above, **1a** is thermally stable and can be sublimed without condensation. However, the anhydride $[CH_3N(\mu\text{-}CONCH_3)_2B]_2O$ was obtained as the bis(dimethylamine) adduct $[CH_3N(\mu\text{-}CONCH_3)_2B]_2O \cdot 2\,(CH_3)_2NH$ (**6**) from the reaction of $[(CH_3)_2N]_2BOB[N(CH_3)_2]_2$ with N,N′,N″-trimethylbiuret. The boron atoms in **6** are four-coordinate (^{11}B NMR), illustrating the binding of the dimethylamine moieties at the two boron atoms. Surprisingly, **6** decomposed on thermal treatment with the formation **4b** rather than a simple loss of dimethylamine; the thermolysis may be described by eq. (2).

$$[CH_3N(\mu\text{-}CONCH_3)_2B]_2O \cdot 2\,(CH_3)_2NH \rightarrow [\{CH_3N(\mu\text{-}CONCH_3)_2\}_2B]^-(CH_3)_2NH_2^+ + 1/3\,[-BN(CH_3)_2-O-]_3 \quad (2)$$

As was to be expected on the basis of the above results, **2** interacted with N,N′,N″-trimethylbiuret in a fashion analogous to the reaction with N,N′-dimethylurea. The reaction proceeded extremely sluggish in boiling toluene and after 8 h reflux less than one half of the biuret had been consumed. The reaction in boiling xylene proceeded somewhat more readily but offered no advantage as compared to the reaction in the melt. Again approximately one half of the boron of the originating **2** was found as the acid **1a,** and the remainder was obtained as a mixture of the salts **4a** and **4b.** The urea moiety of **2** was recovered as N,N′-dimethylurea but some N,N,N′-trimethylurea was also formed.

N,N′-Dimethyl-N″-ethylbiuret reacted with **2** to give the acid **1b** besides a mixture of ammonium salts of **4d** and **4e.** The reaction of **2** with N,N″-dimethyl-N″-phenylbiuret gave identical products and in about the same ratio in toluene solution or in the melt, *i.e.*, the acid **1c** and the salt **4g;** surprisingly, no formation of the salt **4f** was observed in this case.

The acid **1b** did not form isolable complexes with either methylamine or dimethylamine. If the reagents were combined in chloroform solution, only a very small signal for four-coordinate boron was observed in the ^{11}B NMR spectrum at room temperature, besides the signal of the free acid. At −40 °C, however, only one signal at 1.0 or 2.1 ppm, respectively, was observed for mixtures of **1b** with methylamine or dimethylamine, indicative of complete complexation at low temperatures.

The acid **1c** formed an isolable adduct with methylamine (**3c**). Essentially no interaction was observed at room temperature between **1c** and dimethylamine, trimethylamine, or pyridine (as based on ^{11}B NMR studies).

The thermal decomposition of the salt **4g** did not proceed cleanly and the free betaine **5c** could not be obtained in pure state. However, the ^1H NMR spectrum of the thermolysis product suggested that the mixture contained **5c** as two isomers with the (N)H located at either a $N(C_6H_5)$ (majority) or a $N(CH_3)$ site (minor product) adjacent to the boron. However, the mixture contained additional thermolysis products; no effort was made to separate these.

Experimental Section

Reactions and transfers were carried out in an inert atmosphere. 1,5-Dimethyl-2,4-bis(dimethylamino)-1,5-diaza-2,4-dibora-3-oxacyclohexane-6-one (**2**) was obtained from the reaction of N,N′-dimethylurea with either tris(dimethylamino)borane [7] or tetrakis(dimethylamino)-1,3,2-diboroxane [10]; N,N′,N″-trimethylbiuret and N,N′-dimethyl-N″-ethylbiuret were prepared by reaction of 3,5-dimethyl-1,3,5-oxadiazacyclohexa-2,4,6-trione (obtained by a modified [11] reaction of carbon dioxide with methyl isocyanate [12]) with anhydrous methylamine or ethylamine, respectively [12]; and N,N′-dimethyl-N″-phenylbiuret was prepared from phenyl isocyanate and N,N′-dimethylurea [13].

Elemental analysis were performed by the Schwarzkopf Microanalytical Laboratory, Woodside, NY. Melting points (uncorrected) were determined in sealed capillaries on a Mel-Temp block. NMR spectra were recorded on solutions in $CDCl_3$ (unless otherwise noted) on a Varian XL-200 or VXR-400 (^{11}B) or GEMINI-200 (^1H, ^{13}C) instrument. Chemical shift data are given in ppm with positive values indicating downfield from the reference (internal $(CH_3)_4Si$ for ^1H and ^{13}C NMR, external $(C_2H_5)_2O \cdot BF_3$ for ^{11}B NMR). Abbreviations are as follows: s = singlet, d = doublet, t = triplet, q = quartet, p = quintuplet, m = unresolved multiplet; an asterisk denotes a broad signal. Coupling constants J are given in Hz. All ^{13}C NMR spectra were recorded in the proton decoupled mode. EI mass spectral data were obtained on a VG ZAB-2F instrument; data are given to $m/z = 30$ for 5% or greater relative abundances (in parentheses) only.

The reaction of 1,5-dimethyl-2,4-bis(dimethylamino)-1,5-diaza-2,4-dibora-3-oxacyclohexan-6-one (**2**) *with N,N′-dimethylurea*

a) 1,3,5-Trimethyl-2-hydroxy-1,3,5-triaza-2-boracyclohexa-4,6-dione (**1a**)

A mixture of 2.0 g (19.4 mmol) of **2** and 6.6 g (70 mmol) of N,N′-dimethylurea was slowly heated to give a clear melt, which was subsequently kept at a bath temperature of 190–200 °C for 15 h. Unreacted N,N′-dimethylurea (and a small amount of N,N,N″-trimethylurea as well as N,N′,N″-trimethylbiuret) was sublimed off under vacuum and 4.0 g of solid residue remained. This latter was extracted with 400 ml of boiling toluene to leave 2.6 g of insoluble residue, m.p. 215–235 °C. The toluene solution was evaporated and the resultant solid material (1.3 g, 39%) was recrystallized from acetonitrile to give **1b,** m.p. 172–173 °C.

Analysis for $C_5H_{10}BN_3O_3$ (170.96)

Found	C 35.50	H 6.29	N 24.03,
Calcd	C 35.13	H 5.89	N 24.58.

NMR data: δ ^{1}H = 6.05* (1 H, s), 3.29 (3 H, s), 3.05 (6 H, s); δ ^{11}B = 23.3 (s, $h_{1/2}$ = 300 Hz); δ ^{13}C = 155.5, 29.7, 28.6. – Mass spectrum: *m/z* = 172(6), 171(100), 170(23), 143(20), 115(5), 114(34), 113(24), 112(6), 99(9), 87(8), 86(24), 85(24), 84(5), 72(10), 70(19), 69(8), 58(21), 57(12), 56(47), 55(11), 42(12), 30(16).

b) Methylammonium bis(N,N′,N″-trimethylbiuret-1,5-diyl)borate (**4a**)

The toluene-insoluble material of the preceding experiment (a) was extracted with cold acetonitrile to leave 1.3 g (20%) of insoluble material. This latter residue, m.p. 253–258 °C, was recrystallized from acetonitrile/methanol (4:1 by volume) to give pure **4a,** m.p. 260–262 °C decomp.

Found	C 40.76	H 7.40	N 29.40,
Calcd	C 40.14	H 7.35	N 29.79.

NMR (solution in CD_3OD): δ ^{1}H = 3.19 (2 H, s), 2.55 (1 H, s), 2.51 (4 H, s); δ ^{11}B = 0.2 (s, $h_{1/2}$ = 15 Hz); δ ^{13}C = 158.8, 29.6, 29.0, 25.5. Mass spectrum (13 eV): *m/z* = 298(35), 297(8), 185(9), 184(86), 183(21), 171(6), 145(23), 127(9), 88(52), 41(5), 31(100), 30(53).

The same compound **4a** was obtained on treatment of the betaine 1,3,5-trimethyl-2-(N,N′,N″-trimethylbiuret-1-yl)-1,3,5-triaza-2-boracyclohexa-4,6-dione (**5a**) [5] with anhydrous methylamine in chloroform solution as follows: Anhydrous methylamine was bubbled for a few minutes through a solution of **5a** in chloroform. A precipitate formed in an exothermic reaction. Excess amine and chloroform were evaporated to leave an essentially quantitative yield of crude **4a,** m.p. 248–257 °C. (A m.p. 276–278 °C has been reported for **5a** [5]; this seems to be a printing error and the correct datum should be 296–298 °C.)

c) Dimethylammonium bis(N,N′,N″-trimethylbiuret-1,5-diyl)borate (**4b**)

The acetonitrile solution from the preceding experiment (b) was evaporated to leave 1.1 g (16%) of residue. This was recrystallized from acetonitrile/benzene (1:1 by volume) to give **4b,** m.p. 252–253 °C. (A m.p. of 232 °C has previously been reported for **4b** as obtained from tris(dimethylamino)borane and N,N′,N″-trimethylbiuret [5].)

NMR data: δ ^{1}H = 9.45* (1 H, s), 3.17 (3 H, s), 2.83 (3 H, s), 2.46 (6 H, s); δ ^{11}B = −1.3 (s, $h_{1/2}$ = 20 Hz). In CD_3OD: δ ^{1}H = 3.17 (3 H, s), 2.68 (3 H, s), 2.50 (two closely spaced s, 6 H); δ ^{11}B = 0.2 (s, $h_{1/2}$ = 15 Hz); δ ^{13}C = 158.8, 35.5, 29.6, 29.0. – Mass spectrum (14 eV): *m/z* = 298(14), 184(6), 45(100), 44(87), 30(8). – Lit. [5]: δ ^{1}H = 9.2* (1 H, s), 3.03 (3 H, s), 2.69 (3 H, s), 2.36 (6 H, s); δ ^{11}B = −1.0; δ ^{13}C = 156.3, 35.5, 28.8, 28.3.

The same compound **4b** was also obtained in essentially quantitative yield on treatment of the betaine **5a** [5] with anhydrous dimethylamine in chloroform solution. After evaporation of excess amine and solvent, the residue was recrystallized from acetonitrile to give a pure product, m.p. 252–253 °C.

The reaction of 1,5-dimethyl-2,4-bis(dimethylamino)-1,5-diaza-2,4-dibora-3-oxacyclohexan-6-one (**2**) *with N,N′,N″-trimethylbiuret*

a) 1,3,5-Trimethyl-2-hydroxy-1,3,5-triaza-2-boracyclohexa-4,6-dione (**1a**)

A mixture of 1.0 g (4.7 mmol) of **2** and 3.0 g (20.7 mmol) of N,N′,N″-trimethylbiuret was slowly heated in an oil bath. Vigorous gas evolution started at about 150 °C with the formation of syrupy material. The mixture was kept at 200 °C for 2 h. After cooling to room temperature the glassy product was extracted with 300 ml of boiling toluene to leave 2.4 g of colorless residue. The clear toluene solution was evaporated and the residue was sublimed under vacuum. The sublimate was recrystallized from acetonitrile (in order to remove N,N′-dimethylurea) to give 0.4 g (25%) of **1b** (see above).

b) Methylammonium bis(N,N',N''-trimethylbiuret-1,5-diyl)borate (**4a**)

The 2.4 g of (toluene-snsoluble) residue from the preceding experiment (a) was treated with 60 ml of acetonitrile to leave 1.2 g (38%) of a colorless residue. The latter was recrystallized from acetonitrile/methanol (4:1 by volume) to give **4a** (see above).

c) Dimethylammonium bis(N,N',N''-trimethylbiuret-1,5-diyl)borate (**4b**)

The acetonitrile solution from the preceding experiment (b) was evaporated to leave 1.0 g (30%) of solid material which was recrystallized from acetonitrile/benzene (1:1 by volume) to give 0.6 g of pure **4b** (see above).

2-Methylamine-1,3,5-trimethyl-2-hydroxy-1,3,5-triaza-2-boracyclohexa-4,6-dione (**3a**)

Approximately 0.1 g of **1b** was dissolved in a minimal amount chloroform and anhydrous methylamine was slowly bubbled through the solution for 10–15 min. Volatile material was evaporated under vacuum to leave **3a,** m.p. 158–160 °C, in essentially quantitative yield.

NMR data: δ ^{1}H = 3.14 (3 H, s), 2.65 (6 H, s), 2.51 (3 H, s); δ ^{11}B = −0.1 (s, $h_{1/2}$ = 10 Hz); δ ^{13}C = 159.9, 29.5, 28.4, 25.5. – Mass spectrum (13 eV): *m/z* = 171(35), 170(12), 31(100), 30(23).

2-Dimethylamine-1,3,5-trimethyl-2-hydroxy-1,3,5-triaza-2-boracyclohexa-4,6-dione (**3b**)

This compound, m.p. 180–183 °C, was obtained in a fashion analogous to the preparation of the preceding compound employing **1b** and anhydrous dimethylamine.

NMR data: δ ^{1}H = 5.8* (1 H, s), 3.26 (3 H, s), 3.00* (6 H, s), 2.54 (6 H, s); δ ^{11}B = 0.5 (s, $h_{1/2}$ = 120 Hz). – Mass spectrum (13 eV): *m/z* = 199(19), 172(6), 171(100), 170(24), 145(17), 88(29), 85(7), 83(8), 45(91), 44(19).

Bis(1,3,5-trimethyl-1,3,5-triaza-2-boracyclohexa-4,6-dion-2-yl)oxide-bis(dimethylamine) (**6**)

A mixture of 1.5 g (7 mmol) of $[(CH_3)_2N]_2BOB[N(CH_3)_2]_2$ [10], 2.0 g (14 mmol) N,N',N''-trimethylbiuret, and 20 ml of toluene was stirred at room temperature for 7 days. The mixture was then heated in an oil bath of 50–60 °C for 7 h and finally refluxed overnight. An additional 50 ml of toluene was added and the insoluble material was collected, washed with toluene, and dried under vacuum to give 2.5 g (86%) of crystalline **6,** m.p. 170–230 °C decomp.

Analysis for $C_{14}H_{32}B_2N_8O_5$ (414.08)
Found C 40.68 H 8.02 N 26.80,
Calcd C 40.61 H 7.79 N 27.05.

NMR data: δ ^{1}H = 9.3* (1 H, s), 3.14 (3 H, s), 2.71 (6 H, s), 2.45 (6 H, s); δ ^{11}B = −1.4 (s, $h_{1/2}$ = 25 Hz); δ ^{13}C = 156.8, 35.1, 28.9, 28.5.

The mass spectrum of the product showed only traces at *m/z* = 324 (for the oxide) and a small cluster at *m/z* = 211 (for B-tris(dimethylamino)boroxin); the spectrum was dominated by *m/z* = 298 (for the betaine **5a**) and its fragmentation as well as strong peaks at *m/z* = 45, 44 (for dimethylamine). Indeed, heating (150–160 °C) of the material under vacuum gave the salt **4b** and, ultimately, the betaine **5a** besides some unidentified by-products.

Reaction of 1,5-dimethyl-2,4-bis(dimethylamino)-1,5-diaza-2,4-dibora-3-oxacyclohexan-6-one (**2**) *with N,N'-dimethyl-N''-ethylbiuret*

a) 1,5-Dimethyl-2-hydroxy-3-ethyl-1,3,5-triaza-2-boracyclohexa-4,6-dione (**1b**)

A stirred mixture of 1.1 g (5.2 mmol) of **2** and 2.7 g (16 mmol) of N,N'-dimethyl-N''-ethylbiuret was heated in an oil bath of 200 °C for 2 h. After cooling to room temperature, the glassy product was treated with three 60 ml portions of hot toluene. Evaporation of the toluene from the combined solutions gave 0.7 g (36%) of crude **1b,** containing a small amount of its anhydride. Recrystallization of the product from toluene at the air gave pure **1b,** m.p. 150–151 °C.

Analysis for $C_6H_{12}B_3N_3O_3$ (184.99)
Found C 39.58 H 6.62 N 23.04,
Calcd C 38.95 H 6.54 N 22.71.

NMR data: δ ^{1}H = 5.3* (1 H, s), 3.59 (2 H, q, *J* = 7), 3.27 (3 H, s), 3.05 (3 H, s), 1.16 (3 H, t, *J* = 7); δ ^{11}B = 23.6 (s, $h_{1/2}$ = 260 Hz); δ ^{13}C = 155.6, 155.0, 38.9, 39.6, 28.5, 14.9. – Mass spectrum: *m/z* = 186(12), 185(89), 184(23), 170(44), 169(11), 157(16), 156(5), 129(6), 127(7), 114(14), 113(100), 112(25), 100(20), 99(13), 86(20), 85(13), 72(6), 70(41), 69(15), 58(13), 57(7), 56(57), 55(16), 42(27).

b) Methylammonium bis(N,N'-dimethyl-N''-ethylbiuret-1,5-diyl)borate (**4d**)

All volatiles were removed from the toluene-insoluble oily residue from the preceding reaction under vacuum at room temperature. On standing for 3 days, the remaining syrupy material crystallized partially. Acetonitrile was then added to dissolve the

oily part, and 0.75 g (21%) of colorless crystalline material remained. It was collected and recrystallized from acetonitrile/methano (10:1 by volume) to give 0.4 g of **4d,** m.p. 240–244 °C.

NMR data (solution in CD_3OD): δ ^1H = 3.19 (6 H, s), 3.06 (4 H, unresolved q), 2.56 (3 H?, s) + 2.53* (6 H?, s) 9 H total), 1.04 (6 H, t, J = 7); δ ^{11}B = −0.9 (s, $h_{1/2}$ = 20 Hz). – Mass spectrum (14 eV): m/z = 326(4), 325(17), 324(3), 198(8), 31(100), 30(60).

The acetonitrile solution was evaporated to leave *ca.* 1.2 g of viscous liquid. NMR data showed it to consist primarily of the salt **4e** (δ ^{11}B = −1.3 (s, $h_{1/2}$ = 30 Hz); no effort was made to purify the species).

Reaction of 1,5-dimethyl-2,4-bis(dimethylamino)-1,5-diaza-2,4-dibora-3-oxacyclohexan-6-one (**2**) *with N,N′-dimethyl-N″-phenylbiuret*

a) 1,5-Dimethyl-2-hydroxy-3-phenyl-1,3,5-triaza-2-boracyclohexa-4,6-dione (**1c**)

A stirred mixture of 1.0 g (4.7 mmol) of **2,** 3.0 g (14.5 mmol) of N,N′-dimethyl-N″-phenylbiuret, and 60 ml of toluene was heated to reflux for 18 h. Some precipitate formed and, after cooling the mixture to room temperature, the clear solution was decanted. The toluene was evaporated to leave 2 g of colorless solid. This was heated in a sublimator under vacuum to remove some N,N′-dimethylurea and N,N,N′-trimethylurea. The sublimation residue was recrystallized from toluene to give 0.7 g (32%) of **1c,** m.p. 197–199 °C.

Analysis for $C_{10}H_{12}BN_3O_2$ (233.03)
Found C 51.12 H 5.35 N 17.70,
Calcd C 51.54 H 5.19 N 18.03.

NMR data: δ ^1H = 7.5 (3 H, unresolved m), 7.2 (2 H, unresolved m), 3.99* (1 H, s), 3.34 (3 H, s), 3.10 (3 H, s); δ ^{11}B = 23.6 (s, $h_{1/2}$ = 200 Hz). – Mass spectrum: m/z = 234(11), 233(100), 232(28), 176(50), 175(9), 119(36), 118(7), 93(10).

b) Dimethylammonium bis(N,N′-dimethyl-N″-phenylbiuret-1,5-diyl)borate (**4e**)

Some N,N′-dimethylurea and N,N,N′-trimethylurea was sublimed off the toluene-insoluble material from the preceding experiment (a). The sublimation residue was then recrystallized from acetonitrile to give 1.1 g (25%) of **4e,** m.p. 250–252 °C.

Analysis for $C_{22}H_{30}BN_7O_4$ (467.33)
Found C 54.96 H 6.40 N 20.87,
Calcd C 56.54 H 6.47 N 20.98.

NMR data: δ ^1H = 7.27 (5 H, m), 2.92 (3H, s), 2.58 (3 H, s), 1.95 (3H, s); δ ^{11}B = −1.0 (s, $h_{1/2}$ = 40 Hz); δ ^{13}C = 156.6, 156.2, 142.5, 128.9, 127.7, 126.2, 34.8, 29.2, 28.8. – Mass spectrum (13 eV): m/z = 246(23), 207(15), 119(26), 93(14), 88(20), 45(100), 44(80), 30(42).

2-Methylamine-1,5-Dimethyl-2-hydroxy-3-phenyl-1,3,5-triaza-2-boracyclohexa-4,6-dione (**3c**)

This compound was obtained in a manner analogous to the preparation of **3a** (see above) using the B-hydroxy compound **1c.** The product, m.p. 105 °C decomp, was obtained in essentially quantitative yield.

NMR data (solution in CD_3OD): δ ^1H = 7.23 (5 H, m), 3.20 (3 H, s), 2.72* (3 H, s), 2.37 (3 H, s); δ ^{11}B = 2.5 (s, $h_{1/2}$ = 15 Hz). – Mass spectrum: m/z = 261(24), 233(14), 208(12), 207(100), 204(8), 93(7), 88(15), 85(10), 83(17), 45(6), 31(45), 30(9).

This work was supported in part by the U.S. Office of Naval Research and the Alexander von Humboldt Foundation (K.N.). L. K. acknowledges a leave of absence from the Technical University Wrocław, Wrocław, Poland.

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