An unprecedented study of the rearrangement of 5,5-diazidobarbituric acids under various conditions

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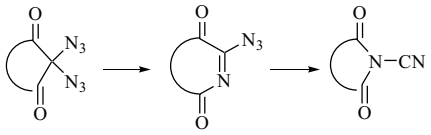
The unexpected parabanic acid derivatives **6a,b** were obtained *via* unprecedented rearrangement of 5,5-diazidobarbituric acids **2a,b** upon stirring in water at 50-60°C. Themolysis of diazides **2a,b** in benzyl alcohol at 120–130°C afforded the tetrazole derivative **11** and/or benzyl allophanate **14.**

Keywords: geminal diazide, 5,5-diazidobarbituric acids, parabanic acids, tetrrazole

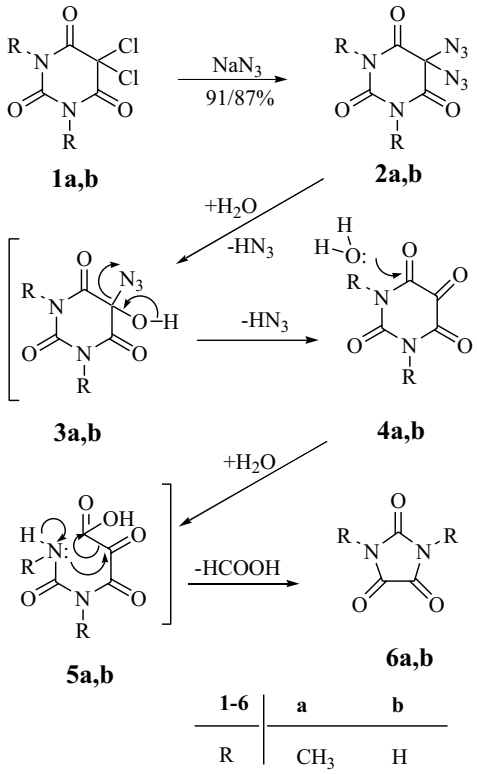
As a consequence of their explosive character primarily geminal diazides have received relatively little attention, although their potential as intermediate in the preparation of tetrazoles and nitriles is recognised.[1-4] The formation of geminal diazides from dichloromalonyl compounds has been reported earlier.[5-7] Cyclic geminal diazides such as 2,2-diazido-1,3-diones, **A**, have been shown ring expansion to azidoimines, **B**, upon thermolysis followed by ring contraction to *N*-cyanoimides, **C**.[7,8]



(**A**) (**B**) (**C**)

To test this rearrangement, as a continuation of our interest in the chemistry of organic azides,[9-11] the geminal diazides **2a,b** were prepared and their thermal chemistry investigated. This study did not demonstrate such rearrangement. Here we describe the rearrangement of 5,5-diazidobarbituric acids to the unexpected parabanic acids and tetrazole derivatives. Thus, the geminal diazides **2a,b** were prepared in excellent yields from the corresponding dichloride **1a,b**[12] upon treatment with sodium azide in acetone. The structures of **2a,b** were confirmed based on the elemental analyses and spectral data. The IR spectra of **2a**,**b** showed an absorption bands at 2110 and 2120 cm^{-1} due to azide groups. Stirring diazides **2a,b** in H_2O at 50–60°C afforded the unexpected parabanic acids **6a,b** in acceptable yields. The validity of structures **6a,b** were deduced from their correct elemental analysis and compatible spectral data, which, were in accordance with an authentic samples prepared as previously described.[13] A reasonable mechanism for this transformation involve the non-isolable intermediate **4** which is converted to **6** *via* nucleophilic attack of H_2O at C-6 with concomitant ring opening of the ring to form the acyclic intermediate **5** was followed by a proton shift and intramolecular rearrangement to give the final product **6** and formic acid. Intermediate **4** was formed, presumably *via* nucleophilic attack of H_2O at C-5 was followed by elimination of hydrazoic acid molecule to give **3**, which, spontaneously releases another molecule of hydrazoic acid, in water and generate C=O group to form **4** (Scheme 1).

Stirring compound **2a** in concentrated solution of $NaHCO_3$ (80%) at 50–60°C for 6 hours gave *N,N*-dimethyloxamide **7**, in moderate yield. Compound **7** could also be obtained by alternative route on stirring of *N,N*-dimethylparbanic acid **6a** in concentrated solution of $NaHCO_3$ (80%) under the same reaction conditions.



Scheme 1

The structure of **7** was established based on its spectral data. The IR spectrum showed stretching bands at 3320 cm^{-1} for NH and 1665 cm^{-1} for C=O groups. In addition, the ^1H NMR spectrum revealed the presence of a douplet at δ = 2.70 ppm corresponding to two identical CH_3 groups and a singlet broad at δ = 8.71 ppm corresponding to two NH groups. Moreover, structure **7** was supported by ^{13}C NMR spectrum which was compatible with assigned structure.

Attention was next turned to study the thermolysis of the diazide **2a** at higher temperature. Thus, heating the diazide **2a** in freshly distilled benzyl alcohol at 120–130°C for 5 hours afforded *N*-methyl-1*H*-tetrazole-5-carboxamide **11** (Scheme 3). The structure of the new compound **11** was confirmed as the reaction product from its IR, ^1H NMR, ^{13}C NMR and correct elemental analysis as well as mass spectrum. Thus, the IR spectrum showed absorption bands at 3290 cm^{-1} for NH and 1665 cm^{-1} for C=O groups. The ^1H NMR spectrum revealed the presence of a doublet at δ = 2.80 ppm corresponding to 2 C*H*$_3$ and a singlet at δ = 7.22 ppm corresponding to N*H* proton. The ^{13}C NMR spectrum gave strong evidence for the formation of compound **11** which showed signals at δ = 26.01, 151.23 and 155.24 ppm corresponding to the carbon of methyl

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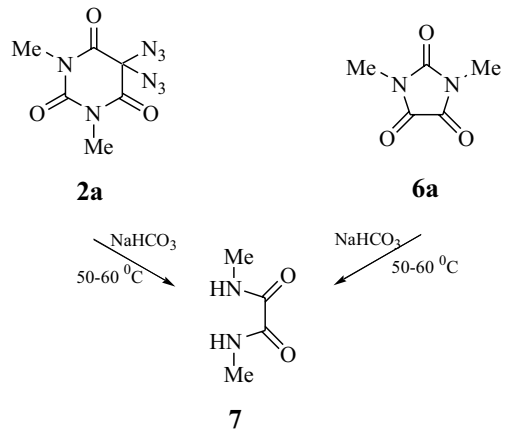
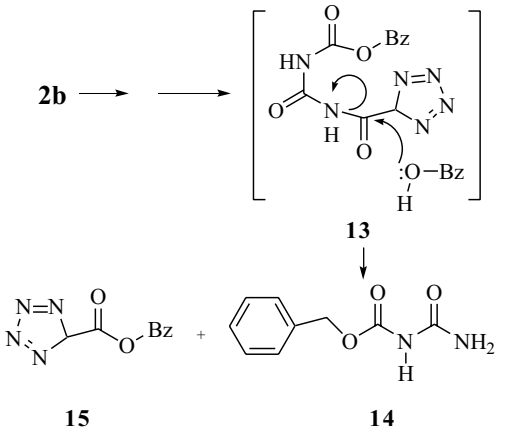


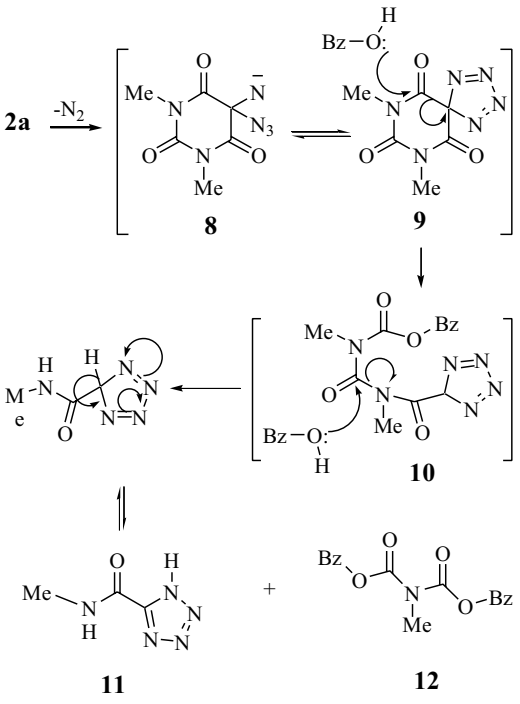
Scheme 2



Scheme 4

group, C-5 of the tetrazole and carbonyl carbon, respectively. Furthermore, its mass spectrum is in accordance with the proposed structure which showed molecular ion peak $m/z = 127$ (15%) correspondinding to the molecular formula $C_3H_5N_5O$. Compound **11** is assumed to be formed *via* initial formation of the triplet azidonitrine **8**, which exists in equilibrium with the spiro compound **9.** The latter intermediate undergoes nucleophilic attack by a molecule of benzyl alcohol on the activated carbonyl group at position 4 to form intermediate **10.** Further nucleophilic attack by another molecule of benzyl alcohol on the carbonyl group in **10** was followed by intramolecular rearrangement to give the final product **11** and **12.** Attempts to detect or isolate compound **12** or any other products were unsuccessful. Presumably, compound **12** is thermally unstable and the thermal degradation of **12** under these reaction conditions prevents its isolation.

On the other hand, thermolysis of **2b** in benzyl alcohol, under the same reaction conditions, afforded the benzyl allophanate **14** and tetrazole derivative **15**, which decomposes under the reaction condition. The chemical structure of **14** was substantiated by elemental analysis and



Scheme 3

spectral data which were consistent with assigned structure (see Experimental). The formation of **14** is assumed to proceed *via* the intermediate **13** which undergoes nucleophilic attack by another molecule of benzyl alcohol to give **14** and compound **15** (Scheme 4). Attempts to isolate compound **15** or any other products were unsuccessful. This can be rationalised on the basis of the thermal unstability of compound **15** under these reaction conditions.

In conclusion, we have developed unprecedented study of the rearrangement of 5,5-diazidobarbituric acids to the unexpected parabanic acids, tetrazoles and benzyl allophanate under various conditions. This study is very convenient for its simplicity, the affordability of the starting materials and opens the way for the studying the chemistry of geminal diazides which are scarcely represented in the literature.

Experimental

Melting points were determined on a Gallenkamp Melting-Point Apparatus, Mod.MFB-595 in open capillary tubes. The IR spectra were recorded on a Perkin-Elmer 298 spectrophotometer using samples in potassium bromide discs. The ^{1}H NMR spectra were recorded on a Varian Gemini 200 at 200 MHz using DMSO-d_6, unless other stated with tetramethylsilane as the internal standard. ^{13}C NMR (360 MHz) were performed on a Bruker AM 360 instrument. Mass spectra analysis was performed with a Kratos 50 TC spectrometer. Microanalyses were performed on a Carlo Erba 1106 analyser. Common reagent-grade chemicals are either commercially available and were used without further purification or prepared by standard literature procedures. All reactions were monitored by thin layer chromatography, carried out on 0.2 mm silica gel 60 F-254 (Merck) plates using UV light (254 and 360 nm) for detection.

5,5-Dichloro-1,3-dimethylbarbituric acid and 5,5-dichlorobarbituric acid **1a,b**: These were prepared by treating 1,3-dimethylbarbituric acid or barbituric with a mixture of concentrated hydrochloric acid and hydrogen peroxide (30%).[12]

5,5-Diazido-1,3-dimethyl barbituric acid (**2a**): Sodium azide (13 g, 200 mmol) was added in small portions to a stirred solution of **1a** (11.2 g, 50 mmol) in acetone (50 ml) at 5–10°C. The stirring was continued for 30 min, and then at room temperature for 4 h, the solid residue was filtered and washed with acetone (50 ml), the filtrate then evaporated under *vacuo*. After standing at 4°C for about 12 h. the pink residue was digested with diisopropyl ether collected by filtration and recrystallised from diisopropyl ether to yield **2a** as a pale pink crystals, (10.4 g, 87%), m.p. 44–46°C; IR: υ_{max} 2110 (N_3), 1700 (CO) cm^{-1}. ^{1}H NMR ($CDCl_3$): $\delta = 3.41$ (s, 6H, 2 NCH_3). Found: C 30.25, H 2.64, N 47.30. Calcd. for $C_6H_6N_8O_3$ (238.16): C 30.26, H 2.54, N 47.05.

5,5-Diazidobarbituric acid (**2b**): To a stirred cold solution of **1b** (1.97 g, 10 mmol) in acetone (20 ml), sodium azide (1.95 g, 30 mmol) was added in small portions. After stirring for 3 h at 10–15°C, the solvent was then removed *in vacuo*, and the resulting residue was digested with cold water. The resulting solid product was collected by filtration, washed with water, dried and recrystallised from $CHCl_3$ to yield **2b** as colourless prisms, (1.92 g, 91%), m.p. 148°C (expl.); IR: υ_{max} 3220, 3120 (NH), 2120 (N_3), 1740 (CO), 1705 (CO) cm^{-1}.

MS(EI, 70 eV): *m/z* (%)154 (1, M^+-2N_2), 140 (5), 124 (13), 112 (2), 86 (3.6), 70 (28), 69 (20), 68 (50), 54 (100). Found: C 23.12 H 1.11 N 53.30. Calcd. for $C_4H_2N_8O_3$ (210.11): C 22.87 H 0.96 N, 53.33.

1,3-Dimethyl parabanic acid (1,3-Dimethyl-2,4,5-trioxoimidazolidine) (**6a**): Diazocompound **2b** (2.4 g, 10 mmol) was stirred at 50–60°C in 20 ml H_2O for 6 h. After cooling at room temperature, the precipitated solid product was collected by filtration, washed with a small amount of H_2O, dried and recrystallised from EtOH to afford **6a** as colourlesss prisms, (0.8 g, 57%), m.p. 152–154°C, [ref.[13] 154°C]. IR: υ_{max} 2980 (CH), 1770, 1735, 1710 (CO) cm^{-1}. ^1H NMR ($CDCl_3$): δ = 3.1 (s, 6H, 2 NCH_3). Found: C 42.07, H 4.22, N 19.80. Calcd. for $C_5H_6N_2O_3$ (142.11): C, 42.26; H, 4.26; N, 19.71.

Parabanic acid (2,4,5-Trioxoimidazolidine) (**6b**): Diazido compound **2b** (1.9 g, 10 mmol) was stirred in H_2O (10 ml) at 50–60°C for 14 hours. After standing at 4°C for about 12 h, the solid obtained was filtered, washed with EtOH, dried and recrystallised from EtOH to yield **6b** as colourless prisms, (0.6 g, 53%), m.p. 243–245°C, [ref. [13], 242–244°C]; IR: υ_{max} 3400 (NH), 3290 (NH), 1720 (CO) cm^{-1}. Found: C 31.23, H 1.89, N 24.31. Calcd. for $C_3H_2N_2O_3$ (114.06) C 31.59, H 1.77, N 24.56

N,N-Dimethyloxamide (**7**): *Method A*: Diazidocompound **2a** (2.4 g, 10 mmol) was stirred in concentrated solution of $NaHCO_3$ (20 ml, 80%) at 50–60°C for 6 h. After cooling to room temperature, the reaction mixture was acidified with HCl (2N) to P^H = 4. Then, the resulting solid product was filtered off, washed with a small amount of H_2O, dried and recrystallised from EtOH to yield **7** as colourless prisms, (0.8 g, 69%), m.p. 208–210°C. *Method B*: A suspension of **6a** (1.4 g, 10 mmol) was stirred in concentrated solution of $NaHCO_3$ (10 ml) at 50–60°C for 4 h. After cooling and acidification with HCl (2 N) (pH = 4), the white precipitate obtained was filtered off, dried to yield (0.6 g, 55%); IR: υ_{max} 3320 (NH), 1665 (CO) cm^{-1}.^1H NMR (DMSO): δ = 2.70 (d, *J* = 5 Hz, 6H, 2 NCH_3), 8.71 (sb, 2H, 2NH); ^{13}C NMR (DMSO): δ = 25.01 (2 CH_3), 160.21 (2 CO). Found: C 41.10, H 6.82, N 24.14. Calcd. for $C_4H_8N_2O_2$ (116.12): C 41.37, H 6.94, N 24.12.

N-methyl-1H-tetrazole-5-carboxamide **11**: The diazido compound **2a** (4.8 g, 20 mmol) was heated with freshly distilled benzyl alcohol (20 ml) in an oil bath at 120–130°C for 5 h, during which the nitrogen gas was evolved. After standing at room temperature for 12 h, the resulting solid product was collected by filtration, washed with ethanol, dried and recrystallised from EtOH to give **11** as colourless prisms, (1.0 g, 42%), m.p. 234–235°C. IR: υ_{max} 3290 (NH), 1665 (CO) cm^{-1}. ^1H NMR (DMSO): δ = 2.80 (d, 3H, CH_3 *J* = 6 Hz), 7.22 (sb, 1H, NH). ^{13}C NMR (DMSO): δ_C 26.01 (CH_3), 151.23 (carbon in tetrazole), 155.24 (CO). MS(EI, 70 eV): *m/z* 127 (15) [M^+], 99 (4) [M^+-N_2], 58 (26), 30 (100), 15 (22) [CH_3]. Found: C 28.67, H 4.05, N 53.13. Calcd. for $C_3H_5N_5O$ (127.10): C 28.35, H 3.96, N 55.10.

Benzyl allophanate (**14**): Compound **2b** (3.15 g, 15 mmol) was heated with benzyl alcohol (10 ml) in an oil bath at 120–130°C for 30 min. After cooling to room temperature, the reaction mixture digested with diethyl ether. The precipitated solid product that obtained was filtered, washed with diethyl ether, dried and recrystallised from MeOH/H_2O to give compound **14** as yellow prisms, (1.2 g, 41%), m.p. 180–181°C, (ref. [14] m.p. 183°C). IR: υ_{max} 3390, 3330 (CH), 1720 (CO), 1690 (CO) cm^{-1}. ^1H NMR (DMSO): δ = 5.02 (s, 2H, CH_2), 7.15 (sb, 2H, NH_2), 7.35 (m, 5H, Ar H), 9.93 (Sb, 1H, NH). Found: C 55.57, H 5.13, N 14.61.Calcd. for $C_9H_{10}N_2O_3$ (194.19): C 55.67, H 5.19, N 14.43.

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