HYDRAZINE DERIVATIVES OF DEHYDRO-L-ASCORBIC ACID

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ABSTRACT

Condensation of L-threo-2,3-hexodiulosono-1,4-lactone (1) with 2 mol of onitrophenylhydrazine gave the bis(o-nitrophenylhydrazone) 2, oxidation of which with cupric chloride afforded 3,6-anhydro-3-(o-nitrophenylazo)-L-xylo-2hexulosono-1,4-lactone 2-(o-nitrophenylhydrazone). Controlled reaction of 1 with o-nitrophenylhydrazine gave the 2-(o-nitrophenylhydrazone) 8, which underwent dehydrative acetylation to yield 4-(2-acetoxyethylidene)-4-hydroxy-2,3-dioxobutyro-1,4-lactone 2-(o-nitrophenylhydrazone). The reaction of 8 with phenyl- and benzoyl-hydrazine afforded the mixed bis(hydrazones) 10 and 11. Oxidative cyclisation of 10 with cupric chloride gave 3,6-anhydro-3-phenylazo-L-xylo-2hexulosono-1,4-lactone 2-(o-nitrophenylhydrazone). The reaction of 8 with methylhydrazine yielded the expected mixed bis(hydrazone) 19, which was dehydrated during the acetylation and gave 4-(2-acetoxyethylidene)-4-hydroxy-2,3-dioxobutyro-1,4-lactone 3-(*N*-acetylmethylhydrazone) 2-(*o*-nitrophenylhydrazone). The condensation of 8 with hydroxylamine and semicarbazide was also studied.

INTRODUCTION

L-threo-2,3-Hexodiulosono-1,4-lactone (1), obtained by the oxidation of vitamin C, is a precursor for nitrogen heterocycles. Reaction of 1 with o-phenylenediamine or its derivatives gave quinoxalines^{1,2} and with semicarbazide, followed by rearrangement, afforded the pyrazole derivatives^{3,4} which had biological activity⁵⁻⁸. The mono- or bis-(phenylhydrazones) of 1 offer routes to various nitrogen heterocycles⁹⁻¹⁵. We now report on the mono- and bis-(o-nitrophenyl-hydrazones) of 1 and their oxidative cyclisation.

RESULTS AND DISCUSSION

When an aqueous solution of 1 was heated with 2 mol of *o*-nitrophenylhydrazine in the presence of acetic acid, the corresponding bis(hydrazone) 2 was obtained, which has i.r. absorptions at 1720 (lactone C=O), 1600 (C=N), and 3155 and 3450 cm⁻¹ (=NH and OH). Compound 2 was characterised as the diacetate 3 and the dibenzoate 4. The n.m.r. spectrum of 3 contained signals for imino protons



at δ 12.23 (C-3 hydrazone residue) and 14.27 (C-2 hydrazone residue). The lowfield position of these signals indicated the imino protons to be chelated and explained the resistance of **2** to *N*-acetylation. Mild oxidation of **2** yielded a yellow 3,6-anhydro-3-(*o*-nitrophenylazo)-L-*xylo*-2-hexulosono-1,4-lactone 2-(*o*-nitrophenylhydrazone) (**5**). The i.r. band at 1745 cm⁻¹ (lactone C=O) for **5** suggested that the lactone ring was intact. As for the phenyl analogue¹⁶, the mass spectrum of **5** contained a peak at m/z 444 for (M + 2)[±] arising, presumably, by disproportionation of M[±]. Compound **5** gave an acetate **6** and a benzoate **7**. The n.m.r. spectrum of **6** contained a signal for an imino proton at δ 13.83.

The reaction of an aqueous solution of 1 with 1 equiv. of o-nitrophenylhydrazine at room temperature afforded L-threo-2,3-hexodiulosono-1,4-lactone 2-(o-nitrophenylhydrazone) (8), which had i.r. bands at 1750 (lactone C=O), 1680 (3-keto group), and 3180 and 3500 cm⁻¹ (=NH and OH). Treatment of 8 with boiling acetic anhydride afforded the optically inactive monoacetate 9, which had i.r. carbonyl bands at 1795 (lactone), 1735 (acetyl), and 1665 cm⁻¹ (3-keto group), similar to those for the acetylation product of the phenyl analogue¹¹, in addition to a band for the double bond. These data indicated that, during the acetylation of 8, dehydration had taken place, to give 4-(2-acetoxyethylidene)-4-hydroxy-2,3dioxobutyro-1,4-lactone 2-(o-nitrophenylhydrazone) (9). The mass spectrum of 9 contained a peak at m/z 333 (M[‡]).

Condensation of 8 with 1 mol of phenylhydrazine gave the mixed bis(hydrazone) 10 which afforded a diacetate 14. The n.m.r. spectrum of 14 contained signals for chelated imino protons at δ 11.07 and 13.90. Mild oxidation of 10 with cupric chloride yielded the bicyclic anhydro derivative 16. Similar to the phenyl and *o*-nitrophenyl analogues, the mass spectrum of 16 contained a peak for $(M + 2)^{\ddagger}$ at m/z 399.

Compound 16 gave an acetate 17 and a benzoate 18, the structures of which were confirmed by elemental analysis, and by the i.r. and n.m.r. spectra. Condensation of 8 with 1 mol of benzoylhydrazine afforded the bis(hydrazone) 11, acetylation of which gave the diacetate 15. The n.m.r. spectrum of 15 contained signals for imino protons at δ 11.84 and 14.15.

The condensation of 8 with hydroxylamine and semicarbazide yielded L-threo-



2,3-hexodiulosono-1,4-lactone 2-(*o*-nitrophenylhydrazone 3-oxime (12) and L-*threo*-2,3-hexodiulosono-1,4-lactone 2-(*o*-nitrophenylhydrazone) 3-semicarbazone (13), respectively.

In contrast to the phenyl analogue, the reaction of **8** with methylhydrazine afforded the expected L-threo-2,3-hexodiulosono-1,4-lactone 3-methylhydrazone 2-(o-nitrophenylhydrazone) (**19**), which had i.r. bands at 1730 (lactone C=O), 1610 (C=N), and 3280 and 3425 cm⁻¹ (=NH and OH). The mass spectrum of **19** contained a peak at m/z 337 (M⁺). Acetylation of **19** yielded an unexpected, optically



inactive *O*, *N*-diacetyl derivative, 4-(2-acetoxyethylidene)-4-hydroxy-2,3-dioxobutyro-1,4-lactone 3-(*N*-acetylmethylhydrazone) 2-(*o*-nitrophenylhydrazone) (**20**), which had i.r. bands at 1795 (lactone C=O), 1735 (OAc), and 1670 cm⁻¹ (NAc), indicating that, during the acetylation of **19**, dehydration had taken place with *N*acetylation of the methylhydrazone residue on C-3. The mass spectrum of **20** contained a peak at m/z 403 (M⁺). The n.m.r. spectrum of **20** contained a signal for a chelated imino proton at *J* 14.47.

EXPERIMENTAL

L-threo-2,3-Hexodiulosono-1,4-lactone 2,3-bis(o-nitrophenylhydrazone) (2). — A solution of L-threo-2,3-hexodiulosono-1,4-lactone (1; 1.74 g, 0.01 mol) in water (50 mL) was treated with o-nitrophenylhydrazine (3.06 g, 0.02 mol) and acetic acid (2 mL). The mixture was heated for 30 min at 100°, and then cooled. The crude product (3 g, 67.5%) was collected, washed successively with water, ethanol, and ether, dried, and recrystallised from 1,4-dioxane to give red needles of 2, m.p. 286–287°; ν_{max}^{KBr} 3450 (OH), 3155 (NH), 1720 (COO), and 1600 cm⁻¹ (C=N).

Anal. Calc. for C₁₈H₁₆N₆O₈: C, 48.7; H, 3.6; N, 18.9. Found: C, 48.3; H, 3.5; N, 19.0.

5,6-Di-O-acetyl-L-threo-2,3-hexodiulosono-1,4-lactone 2,3-bis(o-nitrophenylhydrazone) (3). — A suspension of 2 (0.45 g, 1 mmol) in acetic anhydride (5 mL) was heated under reflux for 1 h and then poured onto crushed ice. The product (0.45 g, 85%) was collected, washed successively with water, ethanol, and ether, and dried. Recrystallisation from chloroform–ethanol gave 3 as red needles, m.p. 223–224°; ν_{max}^{KBr} 1745 (COO, OAc) and 1600 cm⁻¹ (C=N). ¹H-N.m.r. data (CDCl₃, 80 MHz): δ 1.91 (s, 3 H, COMe), 2.06 (s, 3 H, COMe), 4.39 (m, 2 H, H-6.6), 5.39 (d, 1 H, H-4), 5.67 (m, 1 H, H-5), 6.97–8.52 (m, 8 H, aromatic protons), 12.23 (s, 1 H, NH-3), and 14.27 (s, 1 H, NH-2).

Anal. Calc. for $C_{22}H_{20}N_6O_{10}$: C, 50.0; H, 3.8; N, 15.9. Found: C, 50.5; H, 3.6; N, 15.9.

5,6-Di-O-benzoyl-L-threo-2,3-hexodiulosono-1,4-lactone 2,3-bis(o-nitrophenylhydrazone) (4). — To a solution of 2 (0.45 g, 1 mmol) in dry pyridine (10 mL) was added benzoyl chloride (0.28 g, 2 mmol). The mixture was kept overnight at room temperature and then poured onto crushed ice, and the product (0.6 g, 92%) was collected, washed successively with water, ethanol, and ether, and dried. Recrystallisation from chloroform-ethanol gave 4 as red needles, m.p. 225–226°; ν_{max}^{RBr} 3165 (NH), 1730 (COO, OBz), and 1600 cm⁻¹ (C=N).

Anal. Calc. for $C_{32}H_{24}N_6O_{10}$: C, 58.9; H, 3.7; N, 12.9. Found: C, 58.4; H, 3.9; N, 12.4.

3,6-Anhydro-3-(0-nitrophenylazo)-L-xylo-2-hexulosono-1,4-lactone 2-(0-nitrophenylhydrazone) (5). — A suspension of 2 (0.9 g, 2 mmol) in a solution of cupric chloride (0.4 g, 2 mmol) in ethanol (50 mL) was boiled under reflux for 1 h

and then concentrated to small volume, and hot water was added to turbidity. After cooling, the product (0.6 g, 66.7%) was collected, washed with water, ethanol, and ether, and dried. Recrystallisation from ethanol gave **5** as yellow needles, m.p. 166–168°; $\nu_{\text{max}}^{\text{KBr}}$ 3470 (OH), 3245 (NH), 1745 (COO), and 1585 cm⁻¹ (N=N). Mass spectrum: m/z 444 (M + 2)⁺.

Anal. Calc. for C₁₈H₁₄N₆O₈: C, 48.9; H, 3.2; N, 19.0. Found: C, 49.0; H, 3.7; N, 18.5.

5-O-Acetyl-3,6-anhydro-3-(o-nitrophenylazo)-L-xylo-2-hexulosono-1,4-lactone 2-(o-nitrophenylhydrazone) (6). — A suspension of 5 (0.44 g, 1 mmol) in acetic anhydride (5 mL) was heated under reflux for 1 h, and then poured onto crushed ice. The product (0.34 g, 70.8%) was collected, washed with water, and dried. Recrystallisation from ethanol gave 6 as yellow needles, m.p. 152–153°; ν_{max}^{KBr} 3245 (NH), 1740 (COO, OAc), and 1570 cm⁻¹ (N=N). ¹H-N.m.r. data (80 MHz, CDCl₃): δ 2.06 (s, 3 H, COMe), 4.41 (m, 2 H, H-6,6), 5.41 (d, 1 H, H-4), 5.49 (m, 1 H, H-5), 6.99–8.24 (m, 8 H, aromatic protons), and 13.83 (s, 1 H, NH).

Anal. Calc. for $C_{20}H_{16}N_6O_9$: C, 49.6; H, 3.3; N, 17.4. Found: C, 49.9; H, 3.4; N, 16.9.

3,6-Anhydro-5-O-benzoyl-3-(o-nitrophenylazo)-L-xylo-2-hexulosono-1,4-lactone 2-(o-nitrophenylhydrazone) (7). — To a solution of 5 (0.44 g, 1 mmol) in dry pyridine (5 mL) was added benzoyl chloride (0.14 g, 1 mmol); the mixture was kept overnight at room temperature and then poured onto crushed ice. The product (0.44 g, 80.6%) was collected, washed with water, dried, and recrystallised from ethanol to give 7 as yellow needles, m.p. 190–192°; ν_{max}^{KBr} 3260 (NH), 1735 (COO, OBz), and 1580 cm⁻¹ (N=N). ¹H-N.m.r. data (80 MHz, CDCl₃): δ 4.47 (m, 2 H, H-6,6), 5.55 (d, 1 H, H-4), 5.65 (m, 1 H, H-5), 7.07–8.20 (m, 13 H, aromatic protons), and 13.88 (s, 1 H, NH).

Anal. Calc. for C₂₅H₁₈N₆O₉: C, 55.0; H, 3.3; N, 15.4. Found: C, 55.1; H, 3.0; N, 15.5.

L-threo-2, 3-Hexodiulosono-1, 4-lactone 2-(o-nitrophenylhydrazone) (8). — A solution of 1 (1.74 g, 0.01 mol) in water (50 mL) was treated with o-nitrophenyl-hydrazine (1.53 g, 0.01 mol) for 24 h at room temperature. The crude product (1.7 g, 55%) was collected, washed successively with water, ethanol, and ether, dried, and recrystallised from ethanol to give 8 as yellow needles, m.p. 192.5–193.5°; $\nu_{\text{max}}^{\text{KBr}}$ 3500 (OH), 3180 (NH), 1750 (COO), 1680 (C=O), and 1600 cm⁻¹ (C=N).

Anal. Calc. for C₁₂H₁₁N₃O₇: C, 46.6; H, 3.6; N, 13.6. Found: C, 46.9; H, 4.0; N, 13.4.

4-(2-Acetoxyethylidene)-4-hydroxy-2,3-dioxobutyro-1,4-lactone 2-(o-nitrophenylhydrazone) (9). — A suspension of 8 (0.31 g, 1 mmol) in acetic anhydride (5 mL) was heated under reflux for 1 h, and then pourced onto icc. The product (0.3 g, 90.1%) was collected, washed with water, dried, and recrystallised from ethanol to give 9 as yellow needles, m.p. 140.5–141.5°; ν_{max}^{KBr} 3180 (NH), 1795 (COO), 1735 (OAc), 1665 (C=O), and 1605 cm⁻¹ (C=N). ¹H-N.m.r. data (80 MHz, CDCl₃): δ 2.05 (s, 3 H, COMe), 4.73 (d, 2 H, H-6,6), 5.91 (t, 1 H, H-5), 7.28–8.36 (m, 4 H, aromatic protons), and 15.11 (s, 1 H, NH). Mass spectrum: *m/z* 333 (M⁺). *Anal.* Calc. for C₁₄H₁₁N₃O₇: C, 50.5; H, 3.3; N, 12.6. Found: C, 50.4; H, 3.4; N, 12.2.

L-threo-2,3-Hexodiulosono-1,4-lactone 2-(o-nitrophenylhydrazone) 3-phenylhydrazone (10). — A solution of 8 (1.55 g, 5 mmol) and phenylhydrazine (0.54 g, 5 mmol) in ethanol (50 mL) containing acetic acid (2 mL) was boiled for 3 h. The product (1.4 g, 70.1%) was collected, washed successively with water, ethanol, and ether, dried, and recrystallised from ethanol to give 10 as red needles, m.p. 219.5– 220.5° ; ν_{max}^{KBr} 3400 (OH), 1740 (COO), and 1605 cm⁻¹ (C=N).

Anal. Calc. for C₁₈H₁₇N₅O₆: C, 54.1; H, 4.3; N, 17.5. Found: C, 53.4; H, 4.6; N, 17.0.

5,6-Di-O-acetyl-L-threo-2,3-hexodiulosono-1,4-lactone 2-(o-nitrophenyl-hydrazone) 3-phenylhydrazone (14). — A suspension of 10 (0.4 g, 1 mmol) in acetic anhydride (5 mL) was boiled under reflux for 1 h, and then poured onto crushed ice. The product (0.4 g, 83.3%) was collected, washed with water, dried, and recrystallised from ethanol to give 14 as red needles, m.p. 198–200°; ν_{max}^{KBr} 3215 (NH), 1745 (COO, OAc), and 1605 cm⁻¹ (C=N). ¹H-N.m.r. data (80 MHz, CDCl₃): δ 1.94 (s, 3 H, COMe), 2.04 (s, 3 H, COMe), 4.39 (m, 2 H, H-6.6), 5.37 (d, 1 H, H-4), 5.49 (m, 1 H, H-5), 7.07–8.22 (m, 9 H, aromatic protons), 11.07 (s, 1 H, NH-3), and 13.90 (s, 1 H, NH-2).

Anal. Calc. for C₂₂H₂₁N₅O₈: C, 54.7; H, 4.4; N, 14.5. Found: C, 54.7; H, 4.8; N, 14.3.

3,6-Anhydro-3-phenylazo-L-xylo-2-hexulosono-1,4-lactone 2-(o-nitrophenylhydrazone) (**16**). — A suspension of **10** (0.8 g, 2 mmol) in a solution of cupric chloride (0.4 g, 2 mmol), in ethanol (50 mL) was boiled under reflux for 1 h and then concentrated to small volume, and hot water was added to incipient turbidity. The product (0.5 g, 62.5%) was collected, washed with water, dried, and recrystallised from ethanol to give **16** as yellow needles, m.p. 188–190°; ν_{max}^{KBr} 3430 (OH), 3260 (NH), 1740 (COO), 1590 (C=N), and 1575 cm⁻¹ (N=N). Mass spectrum: *m/z* 399 (M + 2)[±].

Anal. Calc. for C₁₈H₁₅N₅O₆: C, 54.4; H, 3.8; N, 17.6. Found: C, 54.3; H, 3.9; N, 17.1.

5-O-Acetyl-3,6-anhydro-3-phenylazo-L-xylo-2-hexulosono-1,4-lactone 2-(onitrophenylhydrazone) (17). — A suspension of 16 (0.4 g, 1 mmol) in acetic anhydride (5 mL) was heated under reflux for 1 h, and then poured onto crushed ice. The solid (0.4 g, 90.9%) was collected, washed with water, dried, and recrystallised from ethanol to give 17 as yellow needles, m.p. 177.5–178.5°; ν_{max}^{KBr} 3240 (NH), 1745 (COO, OAc), 1610 (C=N), and 1580 cm⁻¹ (N=N). ¹H-N.m.r. data (80 MHz, CDCl₃): δ 2.01 (s, 3 H, COMe), 4.36 (m, 2 H, H-6,6), 5.31 (d, 1 H, H-4), 5.41 (m, 1 H, H-5), 6.94–8.21 (m, 9 H, aromatic protons), and 13.84 (s, 1 H, NH).

Anal. Calc. for $C_{20}H_{17}N_5O_7$: C, 54.7; H, 3.9; N, 15.9. Found: C, 54.6; H, 4.0; N, 15.5.

3,6-Anhydro-5-O-benzoyl-3-phenylazo-L-xylo-2-hexulosono-1,4-lactone 2-(onitrophenylhydrazone) (18). — To a solution of 16 (0.4 g, 1 mmol) in dry pyridine (5 mL) was added benzoyl chloride (0.14 g, 1 mmol); the solution was kept overnight at room temperature and then poured onto crushed ice. The product (0.3 g, 60%) was collected, washed with water, dried, and recrystallised from ethanol to give **18** as yellow needles, m.p. 141–142°; ν_{max}^{KBr} 3230 (NH), 1720 (COO, OBz), 1605 (C=N), and 1570 cm⁻¹ (N=N). ¹H-N.m.r. data (80 MHz, CDCl₃): δ 4.48 (m, 2 H, H-6,6), 5.45 (d, 1 H, H-4), 5.65 (m, 1 H, H-5), 7.03–8.20 (m, 14 H, aromatic protons), and 13.85 (s, 1 H, NH).

Anal. Calc. for C₂₅H₁₉N₅O₇: C, 59.9; H, 3.8; N, 14.0. Found: C, 59.7; H, 3.9; N, 13.5.

L-threo-2,3-Hexodiulosono-1,4-lactone 3-benzoylhydrazone 2-(o-nitrophenylhydrazone) (11). — A solution of 8 (1.55 g, 5 mmol) and benzoylhydrazine (0.7 g, 5 mmol) in ethanol (50 mL) containing acetic acid (2 mL) was heated under reflux for 6 h and then cooled. The product (1.3 g, 61.9%) was collected, washed with ether, dried, and recrystallised from chloroform-ethanol to give 11 as yellow needles, m.p. 217–219°; ν_{max}^{KBr} 3400 (OH), 3150 (NH), 1735 (COO), 1670 (CON), and 1605 cm⁻¹ (C=N).

Anal. Calc. for C₁₉H₁₇N₅O₇: C, 53.4; H, 4.0; N, 16.4. Found: C, 52.8; H, 4.8; N, 16.0.

5,6-Di-O-acetyl-L-threo-2,3-hexodiulosono-1,4-lactone 3-benzoylhydrazone 2-(o-nitrophenylhydrazone) (15). — A suspension of 11 (0.4 g, 1 mmol) in acetic anhydride (5 mL) was boiled under reflux for 1 h, and then poured onto crushed ice. The product (0.4 g, 80%) was collected, washed with water, dried, and recrystallised from ethanol to give 15 as yellow needles, m.p. 197–198°; ν_{max}^{KBr} 3180 (NH), 1735 (COO, OAc), 1680 (CON), and 1600 cm⁻¹ (C=N). ¹H-N.m.r. data (80 MHz, CDCl₃): δ 1.96 (s, 3 H, COMe), 2.04 (s, 3 H, COMe), 4.36 (d, 2 H, H-6,6), 5.46 (d, 1 H, H-4), 5.56 (m, 1 H, H-5), 7.46–8.31 (m, 9 H, aromatic protons), 11.84 (s, 1 H, NH-3), and 14.15 (s, 1 H, NH-2).

Anal. Calc. for C₂₃H₂₁N₅O₉: C, 54.0; H, 4.1; N, 13.7. Found: C, 54.3; H, 4.0; N, 13.3.

L-threo-2,3-Hexodiulosono-1,4-lactone 3-methylhydrazone 2-(o-nitrophenylhydrazone) (19). — A solution of 8 (1.55 g, 5 mmol) in ethanol (50 mL) was treated with methylhydrazine (0.3 mL, 5 mmol) and acetic acid (2 mL). The mixture was heated under reflux for 3 h and then cooled, and the product (1.1 g, 65.1%) was collected, washed with water, and recrystallised from acetone–ethanol to give 19 as red needles, m.p. 218–219°; ν_{max}^{KBr} 3425 (OH), 3280 (NH), 1730 (COO), and 1610 cm⁻¹ (C=N). Mass spectrum: m/z 337 (M⁺).

Anal. Calc. for C₁₃H₁₅N₅O₆: C, 46.3; H, 4.5; N, 20.8. Found: C, 46.4; H, 4.6; N, 20.6.

4-(2-Acetoxyethylidene)-4-hydroxy-2,3-dioxobutyro-1,4-lactone 3-(N-acetylmethylhydrazone) 2-(o-nitrophenylhydrazone) (20). — A suspension of 19 (0.35 g, 1 mmol) in acetic anhydride (5 mL) was heated under reflux for 1 h, and then poured onto crushed ice. The solid (0.3 g, 75%) was collected, washed with water, dried, and recrystallised from ethanol to give 20 as red needles, m.p. $141-142^{\circ}$; $\nu_{\text{max}}^{\text{KBr}}$ 1795 (COO), 1735 (OAc), 1670 (CON), and 1600 cm⁻¹ (C=N). ¹H-N.m.r. data (80 MHz, CDCl₃): δ 2.02 (s, 3 H, OAc), 2.27 (s, 3 H, NAc), 3.36 (s, 3 H, NMe), 4.90 (d, 2 H, H-6,6), 5.75 (t, 1 H, H-5), 7.33–8.27 (m, 4 H, aromatic protons), and 14.47 (s, 1 H, NH). Mass spectrum: *m/z* 403 (M[±]).

Anal. Calc. for C₁₇H₁₇N₅O₇: C, 50.6; H, 4.3; N, 17.4. Found: C, 50.5; H, 4.2; N, 16.9.

L-threo-2,3-Hexodiulosono-1,4-lactone 2-(o-nitrophenylhydrazone) 3-oxime (12). — A solution of 8 (1.55 g, 5 mmol) in ethanol (50 mL) was treated with hydroxylamine hydrochloride (0.7 g, 10 mmol), sodium acetate (0.8 g, 10 mmol), and acetic acid (2 mL). The mixture was boiled under reflux for 2 h and then concentrated, water (20 mL) was added, and the solid was collected, washed successively with water, ethanol, and ether, dried, and recrystallised from methanol to give 12 as yellow needles, m.p. $251-252^{\circ}$; ν_{max}^{KBr} 3425 (OH), 3220 (NH), 1750 (COO), and 1610 cm⁻¹ (C=N).

Anal. Calc. for C₁₂H₁₂N₄O₇: C, 44.5; H, 3.7; N, 17.3. Found: C, 44.1; H, 4.0; N, 16.9.

L-threo-2,3-Hexodiulosono-1,4-lactone 2-(o-nitrophenylhydrazone) 3-semicarbazone (13).— A solution of 8 (1.55 g, 5 mmol) in ethanol (50 mL) was treated with semicarbazide hydrochloride (1.2 g, 10 mmol), sodium acetate (0.8 g, 10 mmol), and acetic acid (2 mL). The mixture was boiled under reflux for 3 h, then cooled, and concentrated. The product (1 g, 54.3%) was collected, washed successively with water, ethanol, and ether, and recrystallised from ethanol to give 13 as orange needles, m.p. 219–221°; ν_{max}^{KBr} 3380 (OH), 1700 (COO), 1680 (CON), and 1580 cm⁻¹ (C=N).

Anal. Calc. for C₁₃H₁₄N₆O₇: C, 42.6; H, 3.9; N, 22.9. Found: C, 42.8; H, 3.8; N, 22.6.

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