Unexpected Formation of 1-Amino-4,4,5,5-tetramethyl-3-(5,5,6,6-tetramethyl-1,4,5,6-tetrahydropyridazin-3-yl)pyrrolidin-2-one

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Ring Expansion, Dispiro[2.1.2.1]-octanedione, Hydrazine, Tetrahydropyridazine, Pyrrolidone

The title compound **3** is formed on reaction of octamethyldispiro[2.1.2.1]octane-4,8-dione (**1**) with hydrazine. Its structure is established by X-ray diffraction analysis.

1,1,2,2,6,6,7,7-Octamethyldispiro[2.1.2.1]-octane-4,8-dione (**1**) [1, 2] does not yield the corresponding mono- or bis-thione on reaction with reagents such as Lawesson's or Davy's reagent [2]. In order to obtain thiono derivatives of **1,** which we needed for ESR investigations [3], we started a synthesis *via* Okazaki's route [4], *i.e.* preparation of a hydrazone and subsequent reaction with sulfur monochloride.

No reaction of **1** occured, however, with hydrazine hydrate. Instead, the starting material was recovered quantitatively. Yet a product was formed if dry hydrazine (100%) in boiling absolute ethanol was applied. According to its elemental analysis and high resolution mass spectrum it exhibited the stoichiometric formula $C_{16}H_{30}N_4O$ instead of $C_{16}H_{26}N_2O$ expected for the monohydrazone **2** or $C_{16}H_{28}N_4$ for the dihydrazone. Complex ^1H and ^{13}C NMR spectra and a carbonyl band in the IR spectrum suggested a highly complicated struc-

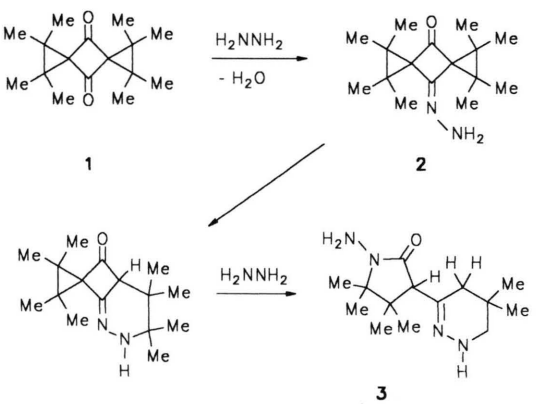

Table I. Crystal data and experimental details.

Formula (M_F)	$C_{16}H_{30}N_4O$ (294.44)
Absorption μ [cm^{-1}]	5.26
Space group	$P\bar{1}$
Z	2
F(000)	162
Lattice constants [pm]	a = 718.5(1)
(from 25 reflections	b = 1034.5(1)
between θ = 20° and	c = 1196.8(1)
and θ = 40°)	α = 95.52(1)°
	β = 92.63(1)°
	γ = 92.56(1)°
Cell volume [pm^3]	$V = 883 \cdot 10^6$
Temperature	298 K
Density [g cm^{-3}]	1.11
Diffractometer	CAD 4 (Enraf Nonius)
Radiation	Cu–$K_{\alpha 1}$, graphite monochromator, λ = 1.540593 Å
Scan technique	$\theta/2\theta$-mode
Index range	$0 < h < +8$
	$-12 < k < +12$
	$-14 < l < +14$
θ-Range	2°–70°
Standard reflections	2
Total reflections	3629
Symmetry independent reflections	3334
Significant reflections (N)	2981 [$I > 3\sigma_I(F_o)$]
Parameters (P)	263
N/P-ratio	11.3
R-value	0.103
R_w-value ($w = \sigma_I^{-2}$)	0.096

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Table II. Positional parameters and their estimated standard deviations.

Atom	*x*	*y*	*z*	B(A2)
O12	0.4394(3)	−0.0839(2)	0.8912(2)	4.31(5)
N1	0.9658(4)	−0.0592(3)	0.8061(3)	5.13(7)
N2	1.0750(5)	−0.1583(4)	0.7646(4)	7.3(1)
N13	0.4047(4)	0.1298(3)	0.8627(3)	4.12(6)
N131	0.2412(4)	0.1487(3)	0.9227(3)	4.77(7)
C3	0.9997(6)	−0.2746(4)	0.7132(4)	6.5(1)
C4	0.8266(7)	−0.2668(5)	0.6475(5)	8.1(1)
C5	0.6997(6)	−0.1682(4)	0.6965(4)	5.03(9)
C6	0.7955(5)	−0.0617(3)	0.7728(3)	3.91(7)
C11	0.6929(5)	0.0526(3)	0.8249(3)	3.88(7)
C12	0.4997(5)	0.0204(3)	0.8622(3)	3.75(7)
C14	0.5151(5)	0.2439(3)	0.8315(3)	4.40(8)
C15	0.6645(5)	0.1729(3)	0.7586(3)	4.41(8)
C31	0.896(2)	−0.3488(6)	0.8196(5)	16.6(3)
C32	1.1471(7)	−0.3643(5)	0.6755(5)	8.4(1)
C41	0.7288(8)	−0.3837(5)	0.5873(4)	7.4(1)
C42	0.925(1)	−0.1875(7)	0.5425(5)	14.9(2)
C141	0.5961(6)	0.3229(4)	0.9371(4)	5.6(1)
C142	0.3865(6)	0.3269(4)	0.7660(4)	6.0(1)
C151	0.5891(7)	0.1319(4)	0.6390(4)	5.8(1)
C152	0.8463(6)	0.2538(4)	0.7558(4)	6.0(1)
H2	1.189(7)	−0.154(5)	0.806(4)	9.0*
H51	0.606(7)	−0.142(5)	0.641(4)	9.0*
H52	0.613(7)	−0.213(5)	0.739(4)	9.0*
H111	0.771(7)	0.086(5)	0.900(4)	9.0*
H321	1.249(7)	−0.355(5)	0.730(4)	9.0*
H322	1.102(7)	−0.446(5)	0.637(4)	9.0*
H323	1.171(7)	−0.291(5)	0.603(4)	9.0*
H411	0.817(7)	−0.452(5)	0.556(4)	9.0*
H412	0.694(7)	−0.419(5)	0.656(4)	9.0*
H413	0.616(7)	−0.375(5)	0.535(4)	9.0*
H1311	0.132(7)	0.082(5)	0.878(4)	9.0*
H1312	0.270(7)	0.149(5)	0.986(4)	9.0*
H1411	0.658(7)	0.400(5)	0.927(4)	9.0*
H1412	0.686(7)	0.273(5)	0.991(4)	9.0*
H1413	0.490(7)	0.345(5)	0.988(4)	9.0*
H1421	0.294(7)	0.278(5)	0.699(4)	9.0*
H1422	0.294(7)	0.370(5)	0.828(4)	9.0*
H1423	0.448(7)	0.388(5)	0.740(4)	9.0*
H1511	0.679(7)	0.078(5)	0.597(4)	9.0*
H1512	0.563(7)	0.200(5)	0.594(4)	9.0*
H1513	0.475(7)	0.069(5)	0.630(4)	9.0*
H1521	0.933(7)	0.200(5)	0.715(4)	9.0*
H1522	0.914(7)	0.276(5)	0.836(4)	9.0*
H1523	0.836(7)	0.328(5)	0.714(4)	9.0*

* Temperature factors were not refined.
Anisotropically refined atoms are given in the form of the isotropic equivalent thermal parameter defined as: $(4/3)\cdot[a2\cdot B(1,1) + b2\cdot B(2,2) + c2\cdot B(3,3) + ab(\cos\gamma)\cdot B(1,2) + ac(\cos\beta)\cdot B(1,3) + bc(\cos\alpha)\cdot B(2,3)]$.

Table III. Selected bond lengths [pm], bond angles [°] and torsion angles [°] of the molecule **3** with standard derivations in brackets.

C12–O12	123.1(5)	C4–C42	172.6(10)
N1–N2	138.6(5)	C5–C6	148.3(6)
N1–C6	126.8(5)	C5–H51	99(6)
N2–C3	137.4(6)	C5–H52	96(6)
N2–H2	93(6)	C6–C11	152.0(5)
N13–N131	141.6(5)	C11–C12	151.0(5)
C12–N13	134.7(5)	C11–C15	155.5(6)
C14–N13	148.0(5)	C11–H111	106(6)
C3–C4	145.0(8)	C14–C15	157.7(6)
C3–C31	173.0(10)	C14–C141	151.5(7)
C3–C32	149.5(7)	C14–H142	153.0(7)
C4–C5	149.4(7)	C15–C151	152.1(7)
C4–C41	178.0(8)	C15–C152	152.3(7)
N1–N2–C3	122.5(4)	N1–C6–C11	113.1(4)
N2–N1–C6	118.7(4)	C5–C6–C11	122.3(4)
C12–C13–N131	123.0(3)	C6–C11–C12	115.7(3)
C14–N13–N131	119.6(3)	C6–C11–C15	119.8(4)
C12–N13–C14	114.2(3)	C12–C11–C15	103.2(3)
N2–C3–C4	115.3(5)	C12–C13–N13	125.4(4)
N2–C3–C31	104.5(5)	C11–C12–O12	127.4(4)
N2–C3–C32	112.0(5)	C11–C12–N13	107.1(3)
C4–C3–C31	94.5(7)	N13–C14–C15	99.9(3)
C4–C3–C32	121.9(5)	N13–C14–C141	109.4(4)
C31–C3–C32	104.4(6)	N13–C14–C142	108.7(4)
C3–C4–C5	114.3(5)	C15–C14–C141	114.2(4)
C3–C4–C41	121.6(6)	C15–C14–C142	114.3(4)
C3–C4–C42	95.6(6)	C11–C15–C14	100.0(3)
C5–C4–C41	114.2(5)	C11–C15–C151	111.1(4)
C5–C4–C42	102.0(6)	C11–C15–C152	111.1(4)
C41–C4–C42	104.2(6)	C14–C15–C151	111.8(4)
C4–C5–C6	114.3(4)	C14–C15–C152	113.1(4)
N1–C6–C5	124.5(4)	C151–C15–C152	109.4(5)
C6–N1–N2–C3	−17.3		
N2–N1–C6–C5	3.6		
N1–N2–C3–C4	34.4		
N2–C3–C4–C5	−36.3		
C3–C4–C5–C6	23.8		
C4–C5–C6–N1	−8.0		
N1–C6–C11–C12	−137.6		
N1–C6–C11–C15	97.8		
N131–N13–C12–O12	16.5		
C14–N13–C12–O12	175.8		
C14–N13–C12–C11	−1.8		
C12–N13–C14–C15	25.2		
C15–C11–C12–N13	−23.1		
C12–C11–C15–C14	36.6		
N13–C14–C15–C11	−36.3		

ture. Therefore, we performed an X-ray structural analysis, which proved the product to be the title compound **3.**

Crystal data and the details of the procedure are compiled in Table I. The structure was solved with the direct method MULTAN [5] and differential Fourier synthesis. Refinement was performed by least-squares methods. Atomic coordinates with standard deviations are listed in Table II [6]. The hydrogen atoms at C-31 and C-42 could not be localized and a final *R*-value of only 0.1 was achieved. This is due to uncertainties in the positions of C-3, C-4, C-31, C-32, C-41, and C-42 (*cf.* the deviations in Table II), which may a-rise from the flexibility of the tetrahydropyridazine ring. As a result unrealistically long (>170 pm) C3–C31, C4–C41, and C4–C42 bonds are found (*cf.* Table III). Nevertheless, the chemical structure of **3**

is unequivocal. An ORTEP plot of the **3**-molecule is shown in Fig. 1. A selection of characteristic structural parameters is given in Table III.

The formation of **3** can be rationalized by assuming a ring enlargement of one cyclopropane ring of **2** as first step, which is followed by addition of hydrazine to the remaining carbonyl group and finally opening of the second cyclopropane and the cyclobutane rings with stabilizing proton shifts. The first step of this sequence is analogous to a similar case reported by Lemieux and Beak [7].

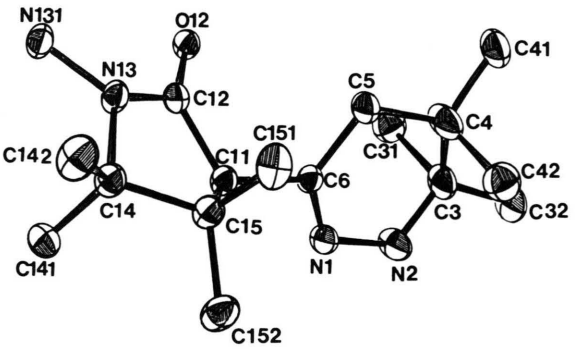

Fig. 1. ORTEP plot of the **3**-molecule.

Experimental

1-Amino-4,4,5,5-tetramethyl-3-(5,5,6,6-tetramethyl-1,4,5,6-tetrahydropyridazin-3-yl)pyrrolidin-2-one (**3**)

1.00 g (4 mmole) **1** [1, 2] was suspended in 30 ml absolute ethanol. After addition of 5 ml 100% hydrazine through a pipette the mixture was refluxed for 72 h. The solution was diluted with 50 ml water and evaporated (vacuum) until a white solid precipitated. The solid was filtered with suction and dried *in vacuo* to yield 0.85 g product, which contained two components (thin layer chromatography). It was washed thoroughly with ethyl acetate and recrystallized from methanol to give 0.40 g (35%) colourless crystals of **3,** m.p. 190 °C. – IR (Perkin-Elmer 399, KBr): ν = 3325 (NH), 3200, 1700 (C=O), 1420, 1380 cm^{-1}. – ^1H NMR (Bruker WH 270, $CDCl_3$, TMS): δ = 0.93 (s, 9H, CH_3), 1.10 (s, 12H, CH_3), 1.15 (s, 3H, CH_3), 2.05 (dd, 2H, 5-H), 3.0 (bs, 1H, NH), 3.8 (bs, 2H, NH_2), 5.10 (s, 1H, 3′-H). – ^{13}C NMR (Bruker WH 270, $CDCl_3$): δ = 20.02 (CH_3), 20.68 (CH_3), 21.25 (CH_3), 22.16 (CH_3), 22.33 (CH_3), 22.96 (CH_3), 24.64 (CH_3), 24.91 (CH_3), 32.56 (C_q), 39.98 (CH_2, C-5), 42.55 (C_q), 54.18 (C_q), 56.98 (CH, C-3′), 64.77 (C_q), 141.0 (C_q, C=N), 171.1 (C_q, C=O).

$C_{16}H_{30}N_4O$ (294.44)

Calcd C 65.27 H 10.27 N 19.03%,
Found C 65.12 H 10.32 N 18.86%.

Mol. weight: Calcd 294.247 Found (HRMS): 294.247.

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