1,3,6,7,9,11,14,15,17,19,22,23,25,27,30,34-Hexadecaazanonacyclo-[25.5.3.$2^{6,9}$.$2^{14,17}$.$2^{22,25}$.$1^{3,7}$.$1^{11,15}$.$1^{19,23}$.$0^{30,34}$]-tetratetracontane

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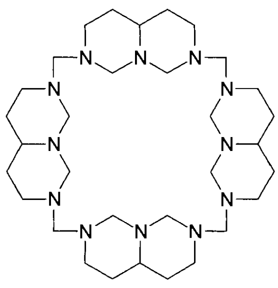
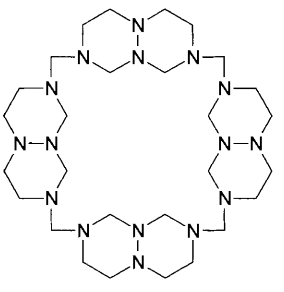
1,1-Bis-(2-aminoethyl)hydrazine condenses with formaldehyde to a polymer that is isomerized to the nonacyclic title compound, showing increased conformational mobility and crystallizing as a tetrahydrate for which the X-ray analysis reveals channels formed by stacked rings and filled by chains of water molecules.

In the preceding communication[1] we reported on a nonacyclic 'tetrameric' condensation product **1** from pentane-1,3,5-triamine and formaldehyde. Out of a total of 16 bridgeheads, only 12 were nitrogen atoms capable of undergoing inversion. Four bridgeheads were CH groups preventing geminal site exchange of CH_2 groups, a process also definable as ring inversion. We now report the synthesis of the corresponding nonacyclic compound **2**, having nitrogen at all 16 bridgehead positions, and present NMR evidence for a geminal exchange process.

1,1-Bis(2-aminoethyl)hydrazine has been reported as a product from the 2-aminoethylation of hydrazine with aziridine.[2] We confirmed that mono(2-aminoethyl)hydrazine can be obtained pure in this way, but found that further reaction led to inseparable product mixtures. Using 2-chloroethylammonium chloride for the second step, the pure bis-compound was obtained as a liquid having the required NMR and MS spectra. To a solution of this bis-compound in water, cooled to 5 °C, aqueous formaldehyde was added dropwise (molar ratio 1 : 3). No precipitate was observed, but evaporation of the water gave quantitatively a gelatinous residue, insoluble in organic solvents. In refluxing dioxane the polymer dissolved slowly and completely, and on cooling the clear solution, crystalline **2** precipitated; mp 214 °C; ^{13}C NMR (75 MHz) in [$^2H_8$]toluene: δ 72.5, 71.7, 54.0, 50.0. MS (EI): 616 (M^+), 462, 308, 211, 154.



1



2

The tetrahydrate of **2** crystallized from moist ethyl acetate and was used for X-ray analysis at −170 °C.† The crystals are isomorphous with those of the tetrahydrate of **1**.[1] but permitted a precise location of the water molecules: two water molecules form a hydrogen-bonded bridge across the cleft of the D_{2d} conformer, joining diagonal hydrazine nitrogens above the ring, the other two water molecules forming a similar bridge below. The hydrazine nitrogens are probably chosen for steric rather than chemical reasons, and this is clearly seen in the stereoview (Fig. 1). Additionally, this picture shows that there is close contact through the ring between one water molecule from each bridge. The second water molecule in each bridge has a similar contact with a water molecule from a bridge in the neighbouring ring, the two D_{2d} macrocycles being related through a centre of symmetry located in the connecting O–H–O 'bond'. Only two such units of a continuous chain are shown in Fig. 1. The nitrogen lone pairs thus provide a polar inner surface of a channel of stacked macrocycles to which the chain of water molecules become anchored. The outer surface of the channel is essentially lipophilic, and the channel stacks are packed parallel.

As to the nature of the polar bonding, each water molecule provides one clear hydrogen bond to one nitrogen. The position of the hydrogen in the bonds that keep the water-chain together cannot be clearly located, presumably owing to the statistical disorder of the dissymmetric position. This is required to produce the observed repeated centres of symmetry along the chain.

The ^{13}C NMR spectrum of **2** at 125 MHz shows at room temperature the four lines expected for fast exchange of any conformer mixture. On cooling a solution in CD_2Cl_2–$CHCl_2F$, the lines broaden and split, but are insufficiently resolved at slow exchange to allow an independent interpretation. We have no reason to believe that the conformational situation is

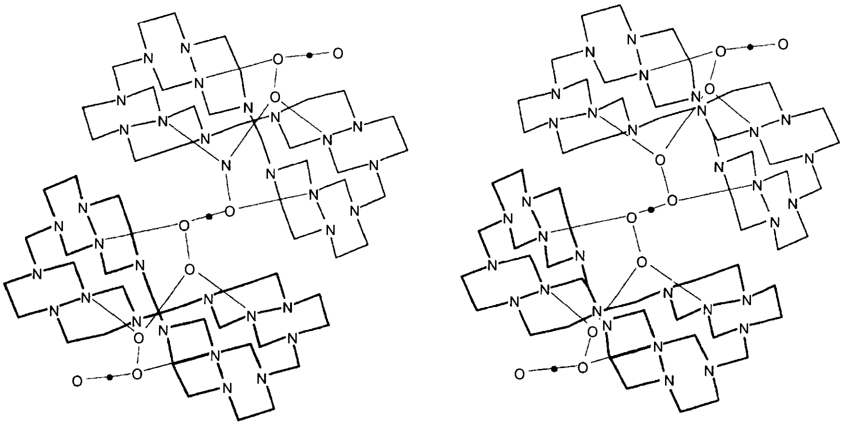


Fig. 1 Stereoview of the crystal structure of the tetrahydrate of **2** as determined by X-ray analysis. Thin lines represent hydrogen bonds OH---O or OH---N.

different from that found for **1**,[1] and attribute the failure to the lower solubility of **2** and to the more narrow spectral range over which the chemical shifts are spread (*ca.* 25 ppm for **2** as against *ca.* 45 ppm for **1**).

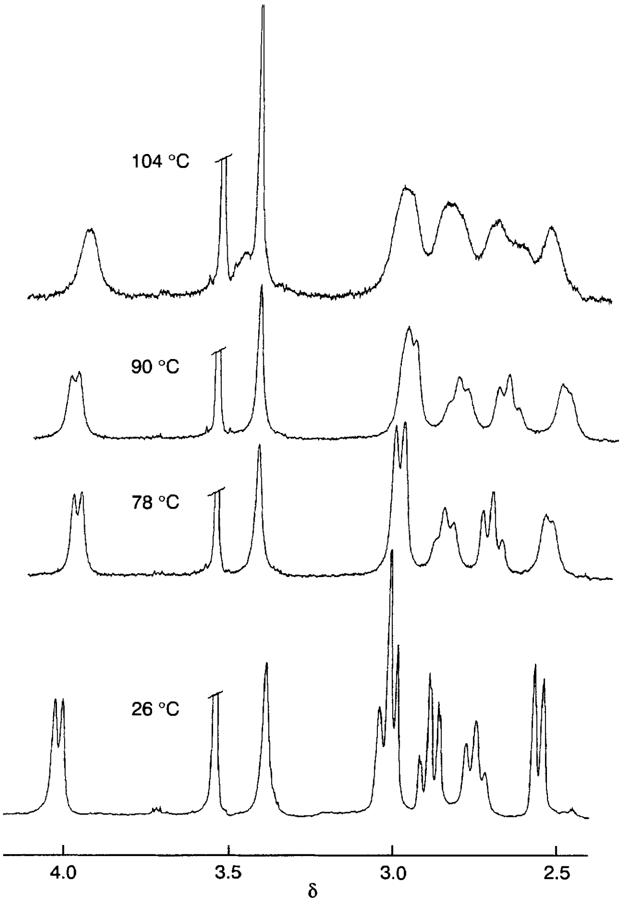


Fig. 2 400 MHz ^1H NMR spectra of **2** in [$^2H_8$]toluene above room temperature. The seven chemical shifts of equal intensity at room temp. must merge to four in the ratio 1 : 2 : 2 : 2 at high temp. The 'corner' NCH_2N gives the singlet at δ 3.40, and the NCH_2N geminal pair is found at δ 4.02 and 3.00. The assignment of the two NCH_2C geminal pairs is unclear; one is at δ 3.03 and 2.75, the other at δ 2.89 and 2.56. In each set the 'triplet' shape betrays the axial, the 'doublet' shape the equatorial proton.

The ^1H NMR spectrum of **2** at 400 MHz at room temperature also represented of course the time-averaged mixture of conformers and on cooling becomes hopelessly complex. On heating a solution of **2** in [$^2H_8$]toluene from 25 to 105 °C a second process of higher activation energy can be observed (Fig. 2), namely the expected site exchange of geminally different CH_2 protons, which cannot occur for **1**. Still higher temperatures would be needed to resharpen the lines of the simplified fast-exchange spectrum. For the analogous quinquecyclic compound[3] sharp lines were developed at 100 °C, going through coalescence already at 30–60 °C ($\Delta G^‡$ *ca.* 60 kJ mol^{-1}). This difference reflects the conformational rigidity of the decalin-like ring system of **2** as compared to cyclohexane-like ring systems.

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Footnote

† *Crystal data* for **2**: $C_{28}H_{56}N_{16}\cdot 4H_2O$, colourless crystals, orthorhombic, space group *Pbcn*, a = 13.672(8), b = 21.15(2), c = 12.552(1) Å, V = 3629(5) Å^3, Z = 4, T = 103 K, crystal dimensions 0.30 × 0.30 × 0.25 mm, 3559 reflections measured, range ($3 < 2\theta < 52°$), 946 observed with $I > 3\sigma(I)$, μ = 0.8 cm^{-1}; final R = 0.040 and Rw = 0.036 (346 parameters, $w = 1/\sigma^2 (F_c{}^2)$; maximum shift/error = 0.10; ρ_{max} = 0.20 e Å^{-3}, ρ_{min} = −0.22 e Å^{-3}. X-ray experimental procedures: Mo-Kα radiation (λ = 0.71069 Å), graphite crystal monochromator, Enraf-Nonius CAD4 diffractometer (ω scan technique). The structure was determined by direct methods (MITHRIL) and anisotropically refined (NRCVAX), drawing made using PLUTO. Atomic coordinates, bond lengths and angles, and thermal parameters have been deposited at the Cambridge Crystallographic Data Centre. See Information for Authors, Issue No. 1.

References

1 J. Dale, C. Rømming and M. R. Suissa, *J. Chem. Soc., Chem. Commun.*, 1995, 1631.
2 K. Eiter and E. Truscheit, *Ger. Pat.*, 1961, 1 108 233.
3 J. Dale, C. Rømming and T. Sigvartsen, *Acta Chem. Scand.*, 1991, **45**, 1071.