Chemistry of Natural Compounds, Vol. 31, No. 3, 1995

CRYSTAL AND MOLECULAR STRUCTURE OF THE COMPLEX SALT OF PEGANINE WITH ZINC CHLORIDE

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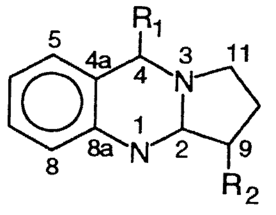
UDC 548.737

The crystal structure of peganine in its complex with $ZnCl_2 \cdot 2H_2O$ *has been established by the x-ray structural method (diffractometer,* CuK_α *radiation, 1796 reflections, direct method,* $R = 0.079$*). A similarity has been found in the solvation of the crystalline complexes with* $ZnCl_2 \cdot HCl$ *of the alkaloids peganine and deoxypeganine. A tendency to the averaging of the* N1=C2 *and* N3–C2 *bonds in quinazolines protonated at* N1 *is observed.*

Tricyclic quinazolines and their reduced analogs, which are present in various species of plants and possess diverse physiological activities [1-3], are attracting the attention of researchers by their interesting chemical transformations. Thus, deoxypeganine (DOP) (**1**) and peganine (**2**) are obtained from deoxyvasicinome and vasicinone, respectively, by reduction with zinc in hydrochloric acid [4]. However, as Shakhidoyatov has shown [5], the reduction of (**4**) under Clemmensen's conditions forms (**1**), and not (**2**), i.e., the hydroxy group in the α-position of the methylene ring is split out.



1. $R_1=R_2=H$
2. $R_1=H$; $R_2=OH$
3. $R_1=O$; $R_2=H$
4. $R_1=O$; $R_2=OH$

We have found experimentally that in the reduction of (**4**) a complex salt of (**2**) with zinc chloride is formed, and only on its decomposition with aqueous ammonia is the splitting out of the hydroxy group observed, i.e., chloroform extraction of an aqueous alkaline solution of the decomposed complex gives a mixture of compounds (**1**) and (**2**) the ratio of which depends on the pH of the initial solution:

$$\mathbf{4} \xrightarrow{Zn/HCl} 2\,(2)^{+} \cdot (ZnCl_4)^{2-} \xrightarrow{NH_4OH} \mathbf{1} + \mathbf{2}$$

In the present paper we give the results of an x-ray structural investigation of the complex salt of peganine (**2**) with zinc chloride (II) obtained under conditions analogous to those for the formation of the complex of (**3**) with zinc chloride [6].

The spatial structure of the complex salt is shown in Fig. 1. Analysis of the crystal structure shows that the complex (in this case, a crystallographically independent unit) consists of a $(ZnCl_4)^{2-}$ anion and two peganine cations (**2a** and **2b**). The N1 atoms of both peganine molecules are protonated. A complex framework similar to that observed in the complex of DOP

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0009-3130/95/3103-0353$12.50

TABLE 1. Bond Lengths r (Å) and Valence Angles ω (degrees) in the Structure of (**2**)

Bond	r_{2a}	r_{2b}	Angle	ω_{2a}	ω_{2b}
N1–C2	1.31(2)	1.35(2)	C8a–N1–C2	119.7(13)	120.2(11)
N1–C8a	1.43(2)	1.42(2)	N1–C2–N3	123.9(14)	121.3(13)
C2–N3	1.33(2)	1.31(2)	C9–C2–N3	111.8(13)	112.5(12)
C2–C9	1.50(2)	1.47(2)	C9–C2–N1	124.3(14)	126.0(13)
N3–C4	1.45(2)	1.49(2)	C2–N3–C4	123.7(12)	126.7(12)
N3–C11	1.44(2)	1.50(2)	C2–N3–C11	113.5(13)	111.4(12)
C4–C4a	1.49(2)	1.55(2)	C4–N3–C11	122.7(13)	121.8(12)
C4a–C5	1.37(2)	1.40(2)	C4a–C4–N3	113.6(14)	107.1(12)
C4a–C8a	1.42(2)	1.35(2)	C5–C4a–C4	123.4(15)	116.3(14)
C5–C6	1.34(3)	1.37(3)	C8a–C4a–C4	119.3(13)	122.7(13)
C6–C7	1.40(3)	1.36(3)	C5–C4a–C8a	117.3(13)	120.9(14)
C7–C8	1.382)	1.37(2)	C6–C5–C4a	124.2(16)	117.5(17)
C8–C8a	1.39(2)	1.40(2)	C5–C6–C7	117.3(16)	122.8(19)
C9–C10	1.57(3)	1.52(2)	C6–C7–C8	121.8(15)	118.7(17)
C9–O1	1.38(2)	1.44(2)	C7–C8–C8a	118.7(15)	120.1(16)
C10–C11	1.53(3)	1.48(3)	C8–C8a–N1	120.1(13)	119.6(13)
			C8–C8a–C4a	120.1(13)	119.9(14)
			C4a–C8a–N1	119.8(12)	120.4(13)
			C2–C9–O1	112.5(13)	110.3(12)
			C2–C9–C10	99.5(13)	100.6(12)
			C10–C9–O1	113.8(14)	113.3(13)
			C9–C10–C11	105.5(14)	107.7(14)
			C10–C11–N3	102.7(14)	101.0(12)
			Anion		
Zn–Cl1	2.260(5)		Cl1–Zn–Cl2	112.8(2)	
Zn–Cl2	2.226(5)		Cl2–Zn–Cl3	110.8(2)	
Zn–Cl3	2.296(4)		Cl2–Zn–Cl4	111.5(2)	
Zn–Cl4	2.287(4)		Cl1–Zn–Cl3	107.1(2)	
			Cl1–Zn–Cl4	109.0(2)	
			Cl3–Zn–Cl4	105.3(2)	

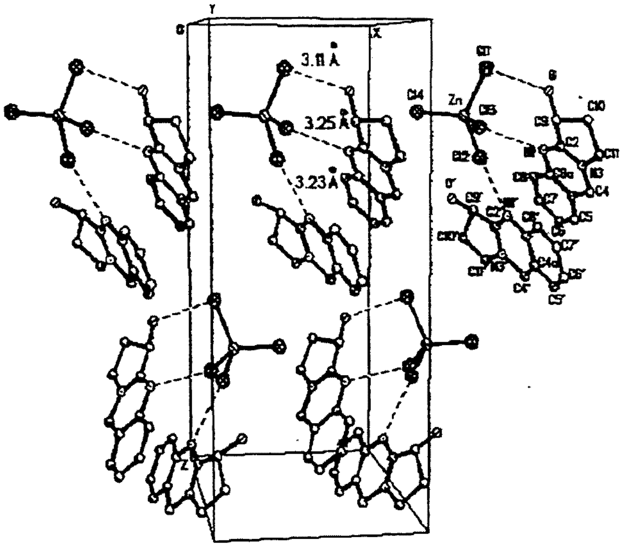

Fig. 1. Packing in the crystal of the complex salt of (**2**) with zinc chloride.

with zinc chloride [6] is formed thanks to hydrogen bonds of the Cl···H–N and Cl···H–O types, as is indicated by the distances: Cl4···N1(2b) 3.23 Å, Cl3···N1(2a) 3.28 Å, and Cl3···O1(2b) 3.37 Å, and also Cl1···O1(1a) 3.11 Å. A similar framework is observed in another peganine salt: in the crystal structure of peganine hydrochloride [7]. The intermolecular distances between the atoms of the different frameworks (complexes) are in the range of van der Waals interactions.

TABLE 2. Coordinates ($\times 10^4$) of the Nonhydrogen Atoms in the Structure of (**2**)

	Cation 2a				Cation 2b			
Atom	*x*	*y*	*z*	U_{eq}.	*x*	*y*	*z*	Ueq
N1	7503(14)	4642(8)	7683(6)	48(4)	−402(14)	4119(8)	9057(6)	47(4)
C2	7052(17)	3760(11)	7575(8)	46(5)	−149(17)	4992(10)	9339(7)	42(5)
N3	6086(13)	3321(8)	7959(7)	48(4)	−624(16)	5211(9)	9949(6)	55(5)
C4	5428(21)	3760(10)	8549(8)	60(6)	−1593(21)	4617(11)	10380(8)	63(6)
C4a	5896(17)	4772(10)	8674(7)	45(5)	−1643(17)	3594(11)	10062(8)	48(5)
C5	5454(18)	5311(13)	9222(9)	60(6)	−2329(20)	2879(14)	10447(10)	69(7)
C6	5818(21)	6239(13)	9329(9)	64(7)	−2392(20)	1966(15)	10176(12)	80(8)
C7	6820(20)	6647(12)	8883(8)	58(6)	−1888(19)	1746(12)	9542(10)	64(6)
C8	7309(17)	6157(10)	8318(9)	49(5)	−1238(18)	2459(11)	9169(9)	60(6)
C8a	6914(15)	5197(10)	8230(7)	40(5)	−1133(15)	3398(10)	9433(7)	38(5)
C9	7575(19)	3120(11)	7012(9)	60(6)	750(15)	5759(11)	9046(7)	45(5)
C10	6336(20)	2364(13)	6995(10)	75(7)	1028(22)	6370(11)	9677(9)	69(7)
C11	5690(21)	2380(12)	7709(10)	76(7)	−149(22)	6197(11)	10163(7)	61(7)
O1	7756(12)	3614(9)	6403(5)	66(4)	2024(12)	5350(8)	8756(6)	70(5)
		Anion						
Zn	1788(2)	4387(1)	6938(1)	44(1)				
Cl1	904(5)	3818(3)	5944(2)	71(2)				
Cl2	4082(4)	4767(3)	6869(2)	66(1)				
Cl3	459(5)	5716(3)	7231(2)	60(1)				
Cl4	1374(5)	3279(3)	7781(2)	60(1)				

It must be mentioned that in the IR spectra of the complex salts of DOP and peganine with $ZnCl_2 \cdot 2HCl$ a pronounced doublet absorption band characteristic for protonated N−H vibrations is observed in the 3130-3290 cm^{-1} region. We explain the doublet nature of the band by the nonidentity of the chemical environments of the N−H bond in the cations of the complexes under investigation, since it follows from the x-ray structural results that in each of these complexes the two independent cations (DOP or peganine) have hydrogen bonds of different lengths with the $ZnCl_4$ anion.

The geometric parameter bond lengths and valence angles in the structure of the complex of (**2**) are given in Table 1, and on averaging they agree well with the corresponding standard values [8] and those observed in another of its solvates — peganine hydrochloride [7]. The lengthening of the N1═C2 double bond and shortening of the N3−C2 bond that are characteristic for quinazolines [6, 7] and quinazolones [9] are due the conjugation of the π-electronic system of the double bond with the unshared pair of the N3 atom. In protonated (**2**) conjugation leads an averaging of the lengths of the N1═C2 (1.33 Å)* and N3−C2 (1.32 Å)* bonds [6,7,10] and to an approximation of their values to those observed in the aromatic pyrimidine (1.336 Å) [8].

Thus, according to Bayer's scheme [11] in quinazolines protonated at the N1 nitrogen the order of the π-bond in N1═C2 decreases (similarly to what is observed in quinazolin-4-ones), while in C2−N3 it increases and amounts on average to 0.6-0.7.

The coordination environment of the Zn atom consists of a slightly distorted tetrahedron.

EXPERIMENTAL

The crystals of (II) were first investigated by the photo method. The space group and the parameters of the unit cell were found from precession x-ray diagrams and were subsequently refined on a Syntex $P2_1$ diffractometer using CuK_α radiation: $a = 9.410(2)$, $b = 13.835(3)$, $c = 19.590(5)$ Å, $d_{calc} = 1.491$ g/cm^3, space group $P2_12_12_1$, $Z = 4$. The intensities of the reflections were measured on the same diffractometer. The number of independent and nonzero reflections with $I > 2\sigma(I)$ was 1657.

The structure was interpreted by the direct method, using the SHELXS program [12] in the automatic regime and was refined by the method of least squares (MLS) in the full-matrix anisotropic approximation by the SHELX-76 program [13].

The coordinates of the H-atoms were inserted geometrically and refined isotropically. The coordinates of the nonhydrogen atoms of the structure of (**2**) from the last stage of the MLS are given in Table 2. All the calculations were performed on a personal computer of the IBM PC AT type. The final value of the divergence factor, R, was 0.079.

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*Mean value for (**2a**) and (**2b**).

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