Research Article

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Synthesis and X-ray structures of unexpected 2-*O*-(5-deoxy-1,2-*O*-isopropylidene-α-D-glucofuranos-5-yloxy)quinoxalines

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Reaction of 3-methyl-2(1*H*)-quinoxalinone (4) and 2(1*H*)-quinoxalinone (5) with 5,6-anhydro-1,2-*O*-isopropylidene-α-D-glucofuranose 6 gives the unexpected *O*-glucoquinoxalines derivatives by the intermediary novel intramolecular rearrangement of 5,6-anhydro-1,2-*O*-isopropylidene-α-D-glucofuranose to the corresponding 3,6-anhydro form. The obtained *O*-glucoquinoxalines 7,8 were identified by NMR spectroscopy. The X-ray crystal structures have been determined at room temperature. Moreover, a solid–solid phase transition has been detected at 198.9 K for *O*-glucoquinoxalines 7 and the structure of the low-temperature phase has been solved at 188 K. Copyright © 2009 John Wiley & Sons, Ltd.

Supporting information may be found in the online version of this article.

Keywords: Quinoxalinones; glucosyl-quinoxalines; synthesis; X-ray structure; phase transition; water solubility.

INTRODUCTION

The quinoxaline derivatives show very interesting biological properties (antibacterial,[1] antiviral, anticancer,[2] antifungal, antihelmintic, antileish-manial,[3] anti-HIV[4]) and their contribution to medicinal chemistry is far reaching.[5] Many drug candidates bearing quinoxaline core structures are in clinical trials in antiviral,[1] anticancer, antibacterial,[2] and central nervous system (CNS) therapeutic areas. Among them, XK469 (**1**) and the chloroquinoxaline sulfonamide (CQS) **2** were known as antineoplastic quinoxaline topoisomerase II inhibitors (Scheme 1).

XK469 is an analog of the herbicide Assure® synthesized by DuPont Company, which possesses antitumor activity, especially against murine solid tumors and human xenografts.[6,7] CQS is a structural analog of sulfoquinoxaline, a compound used to control coccidiosis in poultry, rabbit, sheep, and cattle. CQS was selected for clinical development based on good activity against human tumor cells in the human tumor colony-forming assay[8] and subsequently has shown activity against murine and human solid tumors.[9]

In order to increase the biological activity of various heterocyclic compounds, we have previously linked them on monosaccharide moiety.[10,11]

The aim of this study was to synthesize glucosyl-quinoxalinones of the type **3**, in which *O*-2 grafts to a partially protected glucofuranosyl moiety (Scheme 2). In this paper, we firstly present the synthesis of the 2-*O*-(5-deoxy-1,2-*O*-isopropylidene-α-D-glucofuranos-5-yloxy)-quinoxaline **7** and 2-*O*-(5-deoxy-1,2-*O*-isopropylidene-α-D-glucofuranos-5-yloxy)-quinoxaline **8** (called hereafter compound **7** and compound **8,** respectively, for brevity). Then we provide the results of thermal analysis performed from 173 K up to the melting temperature, which suggests a solid–solid phase transition for compound **7**. Finally, we report on the three crystalline structures at 188 and 293 K for the compound **7** and at 293 K for compound **8**.

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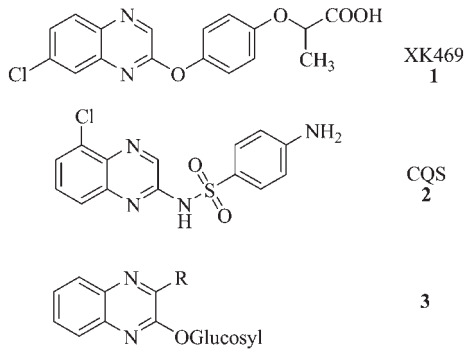


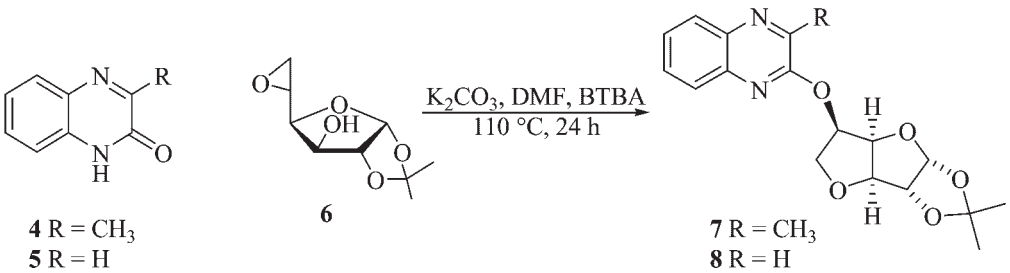
Scheme 1. Example of quinoxaline derivatives

EXPERIMENTAL

Synthesis of compounds *7* and 8

The starting material, 3-methyl-2(1*H*)-quinoxalinone **4** was prepared by condensing ethyl pyruvate with diaminobenzene in hydrochloric acid.[12] The 2(1*H*)-quinoxalinone **5** was prepared by condensing diaminobenzene with glyoxylic acid in *n*-butanol.[13] Refluxing of quinoxalinones **4, 5** with **6**[11] for 24 h in the presence of K_2CO_3 and Bu_4NBr in DMF gives the unexpected *O*-glucoquinoxaline compounds **7** (66% yield) and **8** (68% yield).

For the *synthesis of* **5,6-anhydro-1,2-*O*-isopropylidene-α-D-glucofuranose 6**, glucosidic precursor was synthesized according to the literature.[14,15] The product was isolated as a



Scheme 2. Synthesis of 2-*O*-(5-deoxy-1,2-*O*-isopropylidene-α-D-glucofuranos-5-yloxy)-quinoxalines **7, 8**

Table 1. Crystal structures refinement information and crystallographic data for compounds **7** and **8**

Compound	**7**	**7**	**8**
Empirical formula	$C_{18}H_{20}N_2O_5$	$C_{18}H_{20}N_2O_5$	$C_{17}H_{18}N_2O_5$
Formula weight	344.36	344.36	330.34
Temperature (K)	188	293	293
Crystal system	Monoclinic	Monoclinic	Monoclinic
Space group	C 2	C 2	P 2_1
Z	12	4	2
a (Å)	30.724 (2)	25.626(9)	8.4407(10)
b (Å)	6.5850(4)	6.663(9)	5.5912(8)
c (Å)	28.937(2)	10.526(4)	17.104(2)
β(°)	117.029(2	98.08(9)	95.462(8)
Volume (Å^3)	5215.1(5)	1779(3)	803.5(2)
d (g cm^{-3})	1.316	1.286	1.365
Crystal size (mm)	0.18 × 0.15 × 0.15	0.15 × 0.15 × 0.20	0.20 × 0.15 × 0.10
R_{all}	0.0918	0.0509	0.0383
μ (Cu Kα) (mm^{-1})	0.805	0.786	0.848
$2\theta_{max}$ (°)	117.9	130.3	142.9
No. of reflections used	6942	2651	2975
No. of parameters	687	230	221
Goodness of fit on F^2	1.020	1.075	1.099
Final *R* indices [$I > 2\sigma(I)$]	$R_1 = 0.0831$, w$R_2 = 0.2334$	$R_1 = 0.0437$, w$R_2 = 0.1196$	$R_1 = 0.0340$, w$R_2 = 0.0939$
Max. and min. transmission	0.8888 and 0.8556	0.8912 and 0.8586	0.9200 and 0.8160
F(000)	2184	728	348
$(\Delta/\rho)_{max}$ (Å^{-3})	0.338	0.128	0.178
$(\Delta/\rho)_{min}$ (Å^{-3})	−0.374	−0.125	−0.131
CCDC deposition number	668042	668041	668043

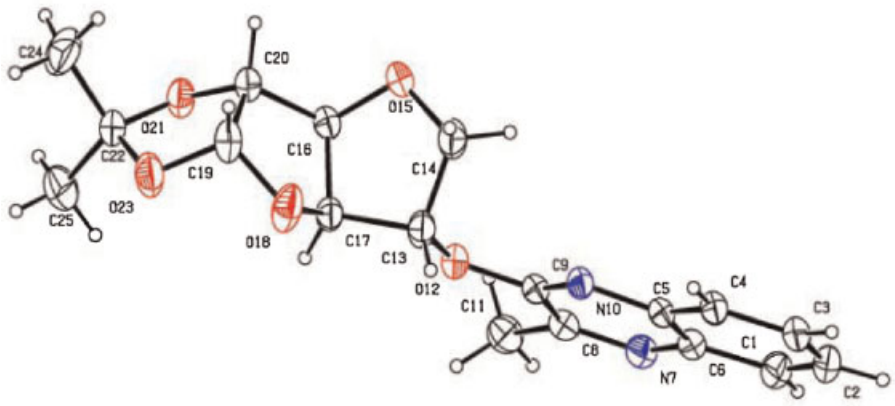


Figure 1. ORTEP plot (with the ellipsoids drawn at the 50% probability level) of **7** at 293 K. This figure is available in colour online at www.interscience.wiley.com/journal/poc

white solid with 96% yield, mp 130–132 °C, $[\alpha]_D^{25}$ −9.3° (c 1.4, $CHCl_3$); ^1H NMR (300 MHz, $CDCl_3$): δ 5.88 (d, 1H, $J_{1,2} = 3.6$ Hz, H-1), 4.43 (d, 1H, $J_{1,2} = 3.6$ Hz, $J_{2,3} = 0.0$ Hz, H-2), 4.18 (d, 1H, 2.3 Hz, H-3), 3.82 (dd, 1H, $J_{3,4} = 2.3$ Hz, $J_{4,5} = 5.3$ Hz, H-4), 3.27 (m, 1H, H-5), 2.88 (dd, 1H, $J_{5,6a} = 4.2$ Hz, $J_{6a,6b} = 4.8$ Hz, H-6a), 2.76 (dd, 1H, H-6b),1.37, 1.22 (2s, 6H, CH_3iso); ^{13}C NMR (75 MHz, $CDCl_3$): δ 110.4 (Ciso), 104.0 (C-1), 84.1 (C-3), 79.2 (C-4), 48.5 (C-5), 45.3 (C-6), 25.7, 25.1 (CH_3iso).

For the *synthesis of* **2-*O*-(5-deoxy-1,2-*O*-isopropylidene-α-D-glucofuranos-5-yloxy)-3-methylquinoxaline 7**, 5,6-anhydro-1,2-*O*-isopropylidene-α-D-glucofuranose **6** (0.70 g, 3.50 mmol) was added to a solution of quinoxalinone **4** (0.459 g, 2.92 mmol), K_2CO_3 (0.48 g, 4.20 mmol) and Bu_4NBr (0.2 g, 0.6 mmol) in DMF (50 ml). The solution was heated to 110°C for 24 h and the reaction was followed by TLC (eluant hexane-acetone: 9:1, v/v). After cooling, the mixture was filtrated and the filtrate was neutralized with saturated NH_4Cl aqueous solution and extracted with toluene. The combined organic extracts were washed with a saturated NaCl aqueous solution. After drying over $MgSO_4$, filtration and evaporation of the solvent, column chromatography on silica gel (9.5:0.5 hexane-acetone) yielded 7(68%) as a white crystal, mp 134 °C; ^1H NMR (300 MHz, $CDCl_3$): δ glucose 5.96 (d, lH, $J_{1,2} = 3.5$ Hz, H-l), 4.94 (t, lH, $J_{4,3} = J_{4,5} = 3.7$ Hz, H-4), 4.58,4.47 (2d, 2H, H-2,3), 4.08–4.02 (ddd, lH, $J_{5,6} = 7.0$ Hz, $J_{6a,6b} = 8.5$ Hz, H-5), 1.52, 1.36 (2s, 6H, Me_2C), quinoxalinone 7.28–7.95 (m, 4H, H-Ar), ^{13}C NMR (75 MHz, $CDCl_3$): δ glucose112.89 (Ciso), 106.92 (C-1), 84.53 (C-3), 83.28 (C-2), 86.73 (C-4), 78.89 (C-5), 73.58 (C-6), 27.71–27.01 (CH_3iso), quinoxalinone 127.30, 127.47, 128.44, 129.48, 139.23, 140.76 (C-5, C-6, C-7, C-8, C-9, C-10), 20.66 (CH_3).

For the *synthesis of* **2-*O*-(5-deoxy-1,2-*O*-isopropylidene-α-D-glucofuranos-5-yloxy)-quinoxaline 8,** 5,6-anhydro-1,2-*O*-isopropylidene-α-D-glucofuranose **6** (0.70 g, 3.50 mmol) was added to a solution of quinoxalinone **5** (0.60 g, 4.20 mmol), K_2CO_3 (0.48 g, 4.20 mmol) and Bu_4NBr (0.2 g, 0.6 mmol) in DMF (50 ml). The solution was heated to 110 °C for 24 h and the

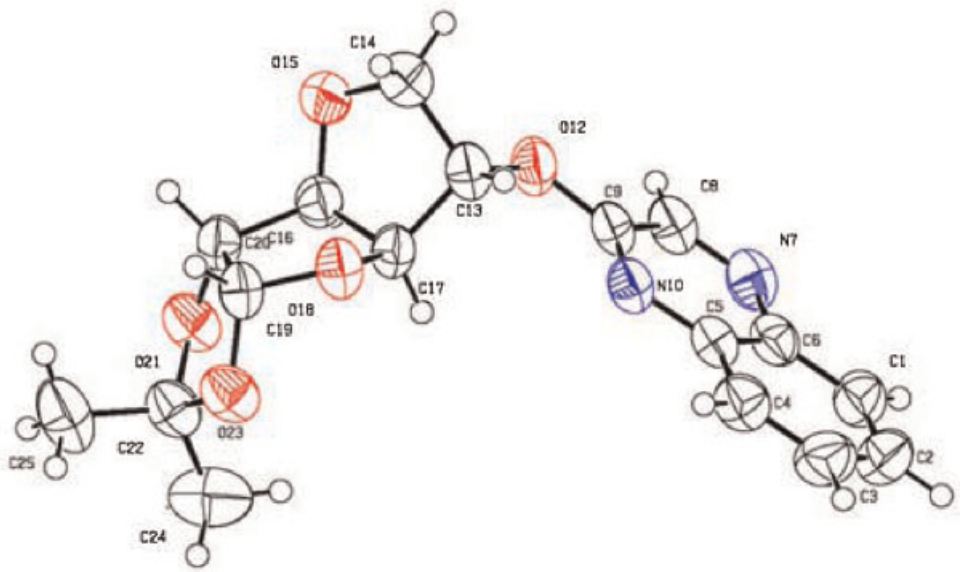


Figure 2. ORTEP plot (with the ellipsoids drawn at the 50% probability level) of **8** at 293 K. This figure is available in colour online at www.interscience.wiley.com/journal/poc

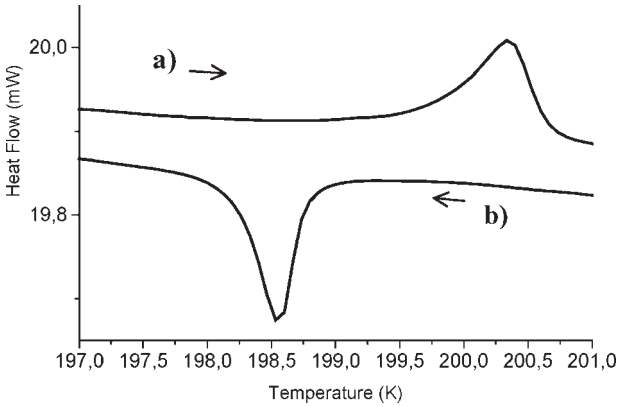


Figure 3. DSC thermogram for **7** showing the solid–solid transition: (a) heating and (b) cooling

Table 2. Melting temperature and enthalpy changes for compounds **7** and **8**

Compound	**7**	**8**
Temperature (K)	371.4 ± 0.4	393.2 ± 0.4
Enthalpy (kJ mol^{-1})	20.4 ± 0.3	29.5 ± 0.4

reaction was followed by TLC (eluant hexane-ether: 9:1, v/v). After cooling, the mixture was filtrated and the filtrate was neutralized with saturated NH_4Cl aqueous solution and extracted with toluene. The combined organic extracts were washed with a saturated NaCl aqueous solution. After drying over $MgSO_4$, filtration and evaporation of the solvent, column chromatography on silica gel (9.5:0.5 hexane-acetone) yielded 8 (68%) as a white crystal, mp 137 °C; ^{1}H NMR (300 MHz, $CDCl_3$): δ glucose 5.97 (d, lH, $J_{1,2} = 3.5$ Hz, H-l), 4.94 (t, lH, $J_{4,3} = J_{4,5} = 3.7$ Hz, H-4), 4.58,4.47 (2d, 2H, H-2,3), 4.08–4.02 (ddd, lH, $J_{5,6} = 7.0$ Hz, $J_{6a,6b} = 8.5$ Hz, H-5), 1.52, 1.43 (2s, 6H, Me_2C), quinoxalinone 7.27–8.03 (m, 4H, H-Ar), 8.50 (s, 1H, CH); ^{13}C NMR (75 MHz, $CDCl_3$): δ glucose 112.91 (Ciso), 106.92 (C-1), 73.60 (C-3), 84.61 (C-2), 86.16 (C-4), 78.81 (C-5), 73.38 (C-6), 27.05–27.74 ppm (CH_3iso), quinoxalinone 127.47, 127.87, 129.38, 139.64, 140.27 (C-5, C-6, C-7, C-8, C-9, C-10).

Thermal analysis

Temperatures as well as enthalpy changes were determined using a PerkinElmer DSC-7 instrument equipped with the cooling accessory allowing temperature rising from 110 to 950 K. Heating rate of 2 K min^{-1} was used. Samples (about 4 mg) were put into aluminum pans and weighed before and after each experiment to control the eventual mass loss. At least four measurements were performed on each compound. The uncertainty on the

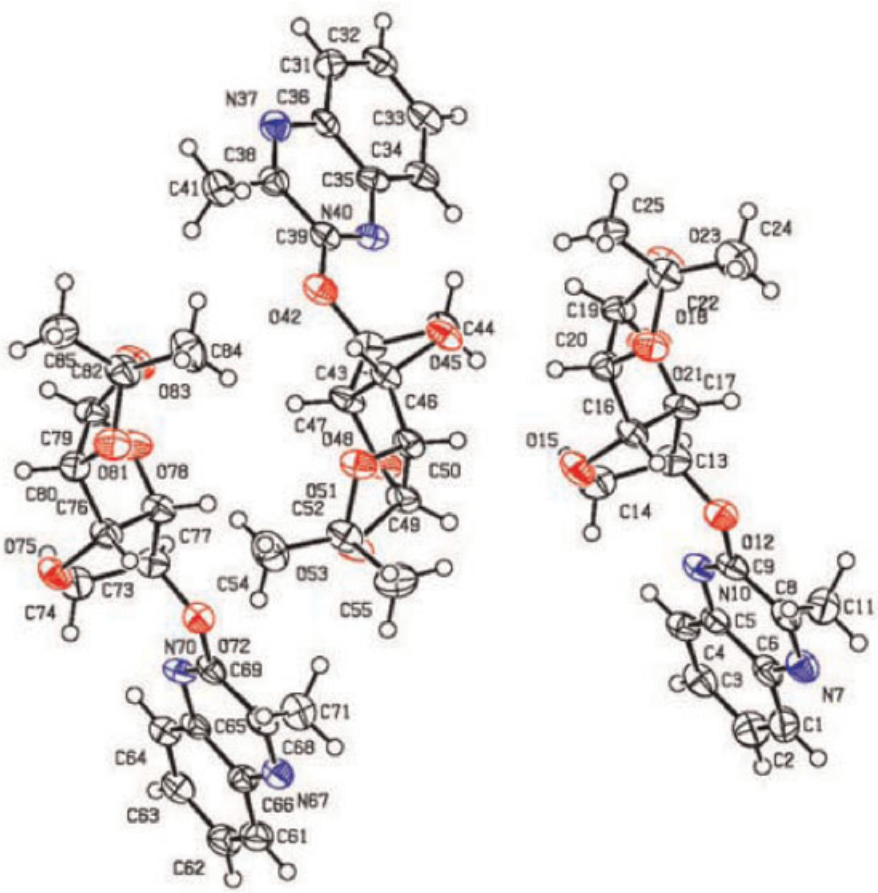


Figure 4. ORTEP plot (with the ellipsoids drawn at the 50% probability level) of the three molecules forming the asymmetric unit of compound **7** at 188 K.

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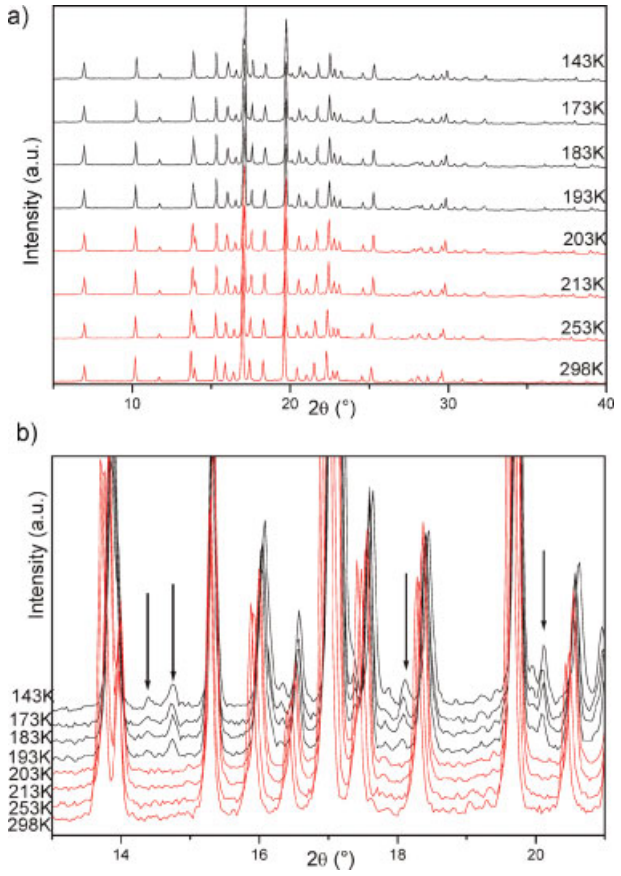

Figure 5. (a) Powder diffraction patterns at various temperatures for **7**. Black and red lines correspond to the low- and high-temperature phases, respectively. (b) Zoom between 15 and 25°, arrows point out some differences between the patterns of the two phases. This figure is available in colour online at www.interscience.wiley.com/journal/poc

temperatures and enthalpies were determined using the Student's method with a 95% threshold of reliability. To this value the systematic error related to the calibration of the apparatus was added, which was set at ±0.2 K for the temperatures and ±1% for the enthalpies.

X-ray diffraction measurements

High-quality powder X-ray diffraction measurements were performed with an Inel CPS 120 powder diffractometer. It was equipped with an Oxford Cryosystems N_2 cryostream to provide isothermal experiments at different temperatures. The Inel CPS 120 works with the Debye–Scherrer transmission geometry and the diffracted beams are collected on a 120° curved counter by gas ionization (argon + C_2H_6). Cu Kα radiation was selected as the incident beam. Samples are introduced in 0.5 mm diameter Lindemann glass capillaries. The latter rotates around its axis in order to minimize preferential orientations of the crystallites. The time of acquisition was set to 6 h in order to obtain reflections with exploitable intensities.

For the structure at 293 K of compound **7**, X-ray crystal measurements were performed with an Enraf-Nonius CAD4 using the 'Enraf–Nonius SDP' program system. The two other crystals have been measured with an R-Axis Rapid-S diffractometer equipped with a rotating anode X-ray tube. The X-ray wavelength was that for Cu Kα ($\lambda = 1.54180$ Å). The structures were solved by direct methods and refined by full-matrix least-squares using SHELXS-97 software. Meanwhile, all of the non-hydrogen atoms were refined anisotropically. The H-atoms were allowed to ride on the parent atoms in the model. Additional details of structure determination are summarized in Table 1.

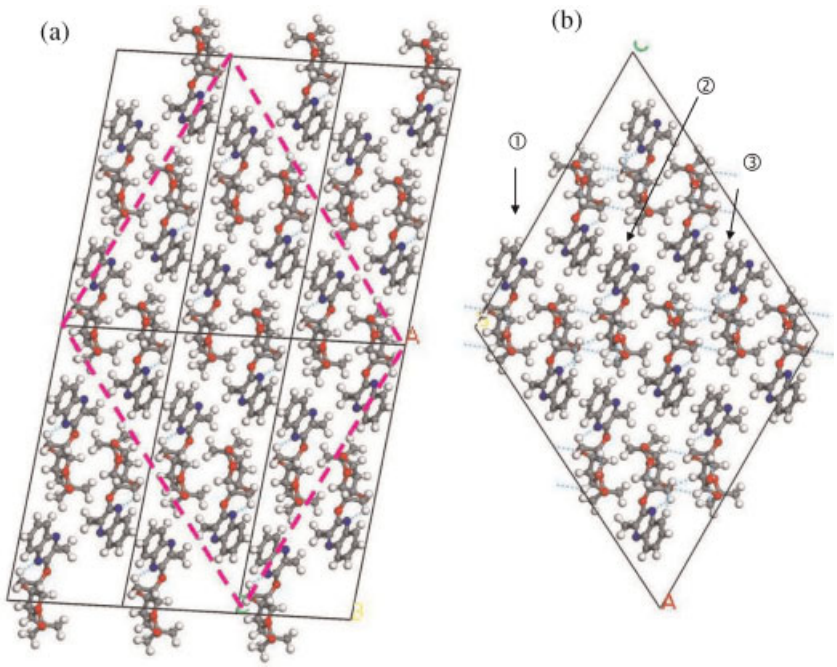

Figure 6. Structures of compound **7**: (a) High-temperature form with three unit cells (the pink dotted line indicates approximately the unit cell of the low-temperature form). (b) Low-temperature form (the three different molecules forming the asymmetric unit are indicated with the numbers ①, ②, and ③).

RESULTS

The chemical structures of the compounds **7** and **8** were deduced from their ^{1}H and ^{13}C NMR and confirmed by X-ray analysis (Figs. 1 and 2).

^{1}H NMR data of compounds **7, 8** clearly showed the presence of δ H-1 at 5.96 ppm (d, 1H, $J_{1,2} = 3.6$ Hz), δ H-5 at 4.02–4.08 ppm (m, 1H) and aromatic protons at 7.27–8.05 ppm (m, 4H).

^{13}C NMR data of these compounds confirm their structures without ambiguity. In particular we observed the disappearance of the carbonyl signal and the appearance of C(5)-O signal at 78.9 ppm.

One of the most significant results of this work was the revelation of an intramolecular rearrangement of 5,6-anhydro-1,2-*O*-isopropylidene-α-D-glucofuranose in the corresponding 3,6-anhydro form.[16,17]

The optical rotatory power of these compounds has been measured and found to be equal to zero indicating that the powders are racemic mixtures.

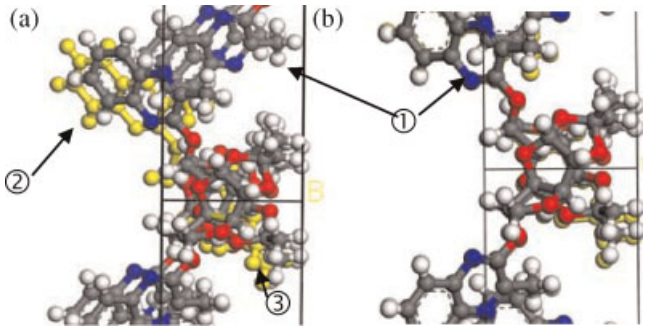

Figure 7. Structure of compound **7** at 188 K. (a) Displacement of molecule ② (in yellow) with regard to molecule ①. (b) Displacement of molecule ③ (in yellow) with respect to molecule ②. This figure is available in colour online at www.interscience.wiley.com/journal/poc

Table 3. Most affected intramolecular distances, angles, and torsion by the solid–solid transition (for the structure at 188 K the labels of the atoms of molecule 1 are the same as those of the molecule at 293 K, the labels of molecule 2 and 3 are added to 30 and 60, respectively)

	At 293 K	Molecule 1 at 188 K	Molecule 2 at 188 K	Molecule 3 at 188 K
Intramolecular distances (Å)				
C(1)-C(6)	1.412(4)	1.386(7)	1.386(6)	1.398(6)
C(5)-C(6)	1.397(4)	1.432(6)	1.426(5)	1.420(5)
C(6)-N(7)	1.372(4)	1.394(6)	1.386(6)	1.397(6)
C(19)-O(23)	1.386(4)	1.411(5)	1.411(5)	1.416(5)
C(19)-C(20)	1.514(4)	1.532(7)	1.536(7)	1.532(6)
C(22)-O(23)	1.419(5)	1.426(6)	1.420(7)	1.444(5)
Intramolecular angles (°)				
O(12)-C(13)-C(14)	112.0(2)	103.5(4)	105.2(4)	111.8(4)
O(12)-C(13)-C(17)	104.6(2)	112.2(4)	112.5(3)	103.4(3)
O(18)-C(17)-C(13)	107.7(2)	103.8(4)	104.6(3)	104.5(3)
Torsions (°)				
C(9)-O(12)-C(13)-C(14)	76.2(3)	79.6(5)	74.2(5)	80.5(5)
C(9)-O(12)-C(13)-C(17)	−174.0(2)	−170.0(3)	−175.1(3)	−171.0(3)
C(13)-C(14)-O(15)-C(16)	13.6(3)	6.3	17.4(5)	13.7(5)
C(14)-O(15)-C(16)-C(20)	118.7(3)	125.8(4)	117.3(4)	119.3(4)
C(14)-O(15)-C(16)-C(17)	6.7(3)	14.6(4)	4.2(4)	7.3(5)
O(15)-C(16)-C(17)-O(18)	89.2(3)	83.5(4)	88.9(4)	87.7(4)
C(20)-C(16)-C(17)-O(18)	−28.5(3)	−33.1(4)	−29.3(4)	−29.2(4)
O(15)-C(16)-C(17)-C(13)	−23.9(3)	−29.6(4)	−24.0(4)	−25.2(4)
C(20)-C(16)-C(17)-C(13)	−142.0(2)	−146.0(3)	−142.2(4)	−142(3)
O(12)-C(13)-C(17)-O(18)	162.5(2)	165.9(3)	164.9(4)	165.5(3)
C(14)-C(13)-C(17)-O(18)	−80.6(3)	−77.1(4)	−77.3(4)	−78.5(4)
C(16)-C(17)-O(18)-C(19)	28.5(3)	34.6(4)	31(4)	30.4(5)
C(13)-C(17)-O(18)-C(19)	138.9(3)	144.0(3)	140.0(4)	140.7(3)
C(17)-O(18)-C(19)-O(23)	98.2(3)	92.2(4)	94(4)	94.4(4)
C(17)-O(18)-C(19)-C(20)	−16.3(4)	−22.0(4)	−19.6(4)	−18.8(4)
O(15)-C(16)-C(20)-O(21)	153.1(2)	156.8(4)	150.6(4)	152.7(4)
O(18)-C(19)-O(23)-C(22)	−130.0(3)	−133(4)	−133.6(4)	−135(4)
C(20)-C(19)-O(23)-C(22)	−13.5(4)	−17.2(4)	−18.2(5)	−20.4(4)
O(21)-C(22)-O(23)-C(19)	27.5(4)	31.3(4)	31.5(5)	35.6(4)
C(24)-C(22)-O(23)-C(19)	−90.6(3)	−87.2(4)	−88.0(4)	−83.8(4)
C(25)-C(22)-O(23)-C(19)	144.5(3)	147.8(4)	148.5(4)	151.1(4)

A first order solid–solid phase transition has been detected by means of thermal analysis for the compound **7** at 198.9 ± 0.4 K with an enthalpy variation of 0.35 ± 0.06 kJ · mol^{-1} (Fig. 3). The melting temperature and enthalpy measured for the two compounds are gathered in Table 2.

The crystallographic data for compounds **7** and **8** at room temperature are given in Table 1 together with those for compounds **7** at 188 K. The ORTEP representations of theses structures are shown in Figs. 1,2 and 4, respectively.

The phase transition has also been observed with X-ray powder diffraction. Figure 5a gathers powder diffractograms recorded between 143 and 298 K. A zoom in the 2θ domain between 15 and 25° permits to reveal that supplementary reflexions appear at low temperature. The diffactograms obtained at various temperature are in agreement with the cell parameters obtained from single crystal data for both phases. The low- and high-temperature solid phases of 2-*O*-(5-deoxy-1,2-*O*-isopropylidene-α-D-glucofuranos-5-yloxy)-3-methyl quinoxaline **7** crystallize in the C2 monoclinic system, that may explain the similarity of the powder diffractograms. Their structures are however different as pointed out in Fig. 5b. The asymetric unit of the low-temperature phase contains three independent molecules (Fig. 4). As a consequence, its crystallographic cell has approximately a triple volume.

Figure 6 illustrates the modification of cell parameters from high to low temperature form: three unit cells of the high-temperature form are shown in Fig. 6a, the pink dotted line indicates approximatively the unit cell of the low temperature form; Fig. 6b shows the unit cell of the low-temperature phase. At the phase transition there are little displacements of the molecules and relative to molecule , which are shown in Fig. 7a and Fig. 7b. In Table 3 some intramolecular parameters (distances, angles, and torsions) affected by the solid–solid transition are collected. In Table 3, the first column is dedicated to intramolecular parameters of the molecule at 293 K and the three others to equivalent parameters of the three independent molecules of the asymmetric unit at 188 K. For the distances, the highest differences between the first column and the three others are observed for C(5)-C(6) (0.035 Å, 0.029 Å, and 0.023 Å). For the intramolecular angles the highest differences are detected for O(12)-C(13)-C(14) (8.5°, 6.8°, 0,2°). It has to be noted that the parameter differences between the low- and high-temperature forms are not similar for the three independent molecules at 188 K.

Intramolecular C—H···N hydrogen bonding chelate withdrawals appear in both forms. However, the low-temperature form presents additional short bond lengths and among them are three intermolecular pseudo hydrogen bonds (Table 4). For comparison between the two forms and also between the molecules at 188 K, we give all the equivalent distances. All the H···A distances given in the bottom part of Table 4 are higher than 2.6 Å. In Fig. 6, the shortest bonds are emphasized with blue dashed lines.

The absolute configuration of the two crystals measured was the same: S, S, S, R, and R for C(13), C(16), C(17), C(19), and C(20), respectively. Although the optical rotatory power of the powder was equal to zero, both single crystals were pure enantiomers extracted from a conglomerate mixture.

The 2-*O*-(5-deoxy-1,2-*O*-isopropylidene-α-D-glucofuranos-5-yloxy)quinoxaline **8** does not present phase transition between 173 K and its melting which occurs at 393.2 ± 0.4 K (Table 2). It crystallizes in a monoclinic $P2_1$ system with $Z = 2$ molecules per

Table 4. (a) Shortest donor–H···acceptor distances and for comparison, other equivalent distances which are not so short

D–H···A	D–H (Å)	H···A (Å)	D···A (Å)	D–H···A(°)	(A) Symmetry code
(a) Shortest donor–H···acceptor distances					
Compound **7** at 188 K					
C20 H20 O45	1.00	2.55	3.285(5)	130.0	*x*, *y*, *z*
C44 $H44_B$ N40	0.99	2.55	3.035(6)	111.0	*x*, *y*, *z*
C13 H13 O21	1.00	2.58	3.509(6)	154.0	*x*, *y* − 1, *z*
C43 H43 O51	1.00	2.58	3.468(6)	149.0	*x*, *y* − 1, *z*
C34 H34 O45	0.95	2.55	3.443(6)	156.0	*x*, *y* − 1, *z*
Compound **7** at 293 K					
C14 $H14_B$ N10	0.97	2.58	3.050(6)	110.0	*x*, *y*, *z*
Compound **8** at 293 K					
C24 $H24_A$ O15	0.96	2.58	3.507(3)	162.0	*x* − 1, *y*, *z*
(b) For comparison, other intermolecular distances which are not so short					
Compound **7** at 188 K					
C50 H50 O75	1.00	2.95	3.541(5)	118.5	*x*, *y*, *z*
C80 H80 O15	1.00	2.76	3.448(5)	126.6	*x*, *y*, *z*
C14 $H14_B$ N10	0.99	2.69	3.118(6)	106.7	*x*, *y*, *z*
C74 $H74_B$ N70	0.99	2.63	3.095(6)	108.1	*x*, *y*, *z*
C73 H73 O81	1.00	2.70	3.589(6)	148.7	*x*, *y* − 1, *z*
C64 H64 O75	0.95	2.73	3.616(6)	155.3	*x*, *y* − 1, *z*
C4 H4 O51	0.95	2.71	3.541(6)	146.9	*x*, *y* − 1, *z*
Compound **7** at 293 K					
C4 H4 O15	0.93	2.71	3.567(6)	153.1	*x*, *y* − 1, *z*
C20 H20 O15	0.98	2.79	3.498(5)	129.2	−*x*, *y*,−*z* + 2
C13 H13 O21	0.98	2.75	3.640(6)	151.8	*x*, *y*−1, *z*

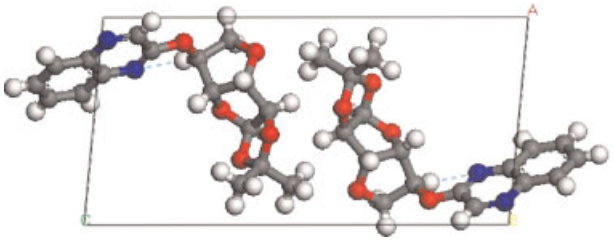

Figure 8. Structure of compound **8** at 293 K, projection along *ac*. This figure is available in colour online at www.interscience.wiley.com/journal/poc

unit cell (Fig. 8). The structure was measured at room temperature; the crystallographic data are presented in Table 1.

Molecules are stacked with a pseudo-hydrogen bond (Table 4). As for compound 7, the single crystal was a pure enantiomer although the optical rotatory power of the powder was equal to zero. The absolute configuration of the measured single crystal is the same that of compound **7** single crystals.

CONCLUSIONS

An intramolecular rearrangement of 5,6-anhydro-1,2-*O*-isopropylidene-α-D-glucofuranose in the corresponding 3,6-anhydro has been put forward in the synthesis of 2-*O*-(5-deoxy-1,2-*O*-isopropylidene-α-D-glucofuranos-5-yloxy)-quinoxaline **7**, and **8**. The crystal structure of these compounds have been determined at room temperature, they both crystallize in a monoclinic system, C2 and $P2_1$, respectively. The compound **7** shows a first-order solid–solid phase transition at 198.9 ± 0.4 K with a low enthalpy variation of 0.35 ± 0.06 kJ · mol^{-1}. The crystal structure of the low-temperature form has also been determined, it crystallizes in the C2 group but the asymmetric unit is composed of three independent molecules.

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