Available online at www.sciencedirect.com
SCIENCE DIRECT
Journal of Molecular Structure 737 (2005) 75–81
Journal of MOLECULAR STRUCTURE
www.elsevier.com/locate/molstruc

V. Thioanalogues of sparteine lactams. (+)-2-Thiono-17-oxosparteine and (+)-2,17-dithionosparteine

Renata Kolanoś[a], Waleria Wysocka[a], Teresa Borowiak[b,*], Grzegorz Dutkiewicz[b], Tadeusz Brukwicki[a]

[a]Department of Chemistry of Alkaloids, Faculty of Chemistry, Adam Mickiewicz University, Grunwaldzka 6, 60-780 Poznań, Poland
[b]Department of Crystallography, Faculty of Chemistry, Adam Mickiewicz University, Grunwaldzka 6, 60-780 Poznań, Poland

Received 23 July 2004; revised 25 October 2004; accepted 26 October 2004
Available online 19 November 2004

Abstract

The X-ray and spectroscopic results clearly indicate that the (+)-2-thiono-17-oxosparteine (**1**) and (+)-2,17-ditihionosparteine (**2**) are conformationally rigid. In order to analyze deviations of lactam/thiolactam groups from planarity induced by ring constraints, the Dunitz–Winkler approach has been used. The lactam and thiolactam groups are close to planarity, only the lactam group in one of the two independent molecules of **1** is markedly non-planar. The bond angles in the thiolactam and lactam groups are highly diverse. Rings A and C adopt a distorted sofa conformation in both compounds. The distortions in the molecules of **2** as compared with those in the related monothiolactams correspond to the unusual chemical shifts of H5(eq), H5(ax) and H11, as well as to the extremely low $J_{5ax\text{-}6}$ and extremely large $J_{5eq\text{-}6}$ coupling constants. Also chemical shifts show a similar regularity being extremely high and low for C2 and C17, respectively.

Keywords: Tertiary thiolactam and lactam groups; Bis-quinolizidine alkaloids; (+)-2-Thiono-17-oxosparteine; (+)-2,17-Dithionosparteine; Conformation of; X-ray analysis; NMR

1. Introduction

The present work is a continuation of our studies on sparteine thiolactams. Structural information from X-ray diffraction as well as IR and NMR spectra has been previously obtained for (+)-2-thionosparteine and its perchlorate, having the thioamide group located in the ring A of a rigid *trans*-quinolizidine part of the sparteine skeleton [1,2]. Another isomeric thiolactams of sparteine, (+)-17-thionosparteine and (+)-15-thionosparteine and their perchlorates have also been lately characterized [3,4].

The amide groups are known to exist preferentially in planar forms. Structural studies of thionosparteines containing the ring tertiary thioamide (thiolactam) groups have been of interest in indicating how these groups adapt themselves to the constraints imposed by the condensed bis-quinolizidine systems. We have also aimed at searching for weak intermolecular interactions in which the sulfur atoms of thiono groups are involved.

In this paper we present the spectroscopic and X-ray study of (+)-2-thiono-17-oxosparteine (hereafter **1**) and (+)-2,17-dithionosparteine (hereafter **2**) (Scheme 1).

Compounds numbered **3**–**8** have been used for comparisons in the interpretation of NMR spectra.

2. Experimental

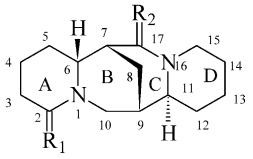
2.1. General techniques and information

Melting points were determined on a Boetius apparatus (PHMK 05 VEB Wagetechnik Rapido, Radebeul). The IR spectra were recorded by means of an FT-IR Bruker IFS 113 v spectrometer (KBr pellets technique). Electron-impact mass spectra were taken on an AMD 402 spectrometer at standard parameters. The ^{13}C NMR and DEPT spectra were measured on a Varian Gemini 300 spectrometer at

* Corresponding author. Tel.: +48 61 8291286; fax: +48 61 8658008.
E-mail address: borowiak@amu.edu.pl (T. Borowiak).

0022-2860/$ - see front matter © 2004 Elsevier B.V. All rights reserved.
doi:10.1016/j.molstruc.2004.10.034

1 R_1=S, R_2=O
2 R_1=S, R_2=S
3 R_1=H_2, R_2=O
4 R_1=O, R_2=H_2
5 R_1=O, R_2=O
6 R_1= S, R_2=H_2
7 R_1=H_2, R_2=S
8 R_1=R_2=H_2



Scheme 1.

a measuring frequency of 75.462 MHz (in $CDCl_3$) and ^1H NMR, ^1H–^1H COSY, NOESY and HSQC spectra in $CDCl_3$-on a Bruker Avance 600 spectrometer at a measuring frequency of 600.31 MHz at standard conditions. The ^1H–^1H coupling constants were either measured directly from the 1D ^1H NMR spectrum after zero filling and apodization (exponential −1.40 Hz, Gaussian 1.00 Hz and 10%) using MestRe-C program [5] or were obtained by means of the line fitting tool [5].

2.2. (+)-2,17-Dioxosparteine (*5*)

(+)-2-Oxosparteine (lupanine, **4**) was isolated from seeds of *Lupinus angustifolius* cv. Turkus according to the method described previously [6]. 17-Oxosparteine (**3**) was obtained from commercial sparteine according to the method described by Gołębiewski [7].

(+)-2,17-Dioxosparteine was prepared from (+)-2-oxosparteine according to the procedure described previously [7]. (+)-2,17-Dioxosparteine was obtained with yield 80% mp. 147 °C, $[\alpha]_D^{20}$ = +154.6° (*c* 0.5, C_2H_5OH). IR (KBr): ν = 1645 cm^{-1} (C=O). MS: *m/z* (%) = 262 [M^+], 150 (100). $C_{15}H_{22}N_2O_2$ (262): calcd. C 68.67, H 8.45, N 10.68; found: C 68.30, H 8.62, N 10.54.

2.3. (+)-2-Thiono-17-oxosparteine (*1*)

Three millimoles (0.786 g) of (+)-2,17-dioxosparteine were dissolved in 30 ml of toluene and 1.5 mmoles (0.606 g) of solid Lawesson's reagent were added. The reaction mixture was stirred continuously at 110 °C for 2 h. The excess of Lawesson's reagent was removed on the column filled with 60 g of Al_2O_3 (neutral) using mixture of ethyl ether and dichloromethane (1:1). Subsequent elution of **1** and crystallization from mixture of hexane and ethyl ether (1:2) gave 0.626 g (75%) of yellow crystals of (+)-2-thiono-17-oxosparteine, mp. 219 °C, $[\alpha]_D^{20}$ = +409.1° (*c* 1, C_2H_5OH). IR (KBr): ν = 1152 cm^{-1} (C=S), ν = 1497 cm^{-1} (N–C=S), ν = 1637 cm^{-1} (C=O). MS: *m/z* (%) = 278 (94) [M^+], 245 (18), 151 (19), 150 (100), 129 (24), 128 (28). $C_{15}H_{22}N_2OS$ (278): calcd. C 64.71, H 7.96, N 10.06; found: C 64.70, H 7.82, N 9.86.

2.4. (+)-2,17-Dithionosparteine (*2*)

Three millimoles (0.786 g) of (+)-2,17-dioxosparteine were dissolved in 40 ml of toluene and 3 mmoles (1.212 g) of solid Lawesson's reagent were added. The reaction mixture was stirred continuously at 110 °C for 15 h. The excess of Lawesson's reagent was removed on the column filled with 80 g of Al_2O_3 (neutral) using ethyl ether. Subsequent elution of **2** and crystallization from mixture

Table 1
Crystal data and structure refinement

	1	**2**
Empirical formula	$C_{15}H_{22}N_2OS$	$C_{15}H_{22}N_2S_2$
Formula weight	278.41	294.47
Temperature (K)	293(2)	293(2)
Wavelength (Å)	1.54178	0.71073
Crystal system, space group	Monoclinic, $P2_1$	Orthorhombic, $P2_12_12_1$
Unit cell dimensions	a = 10.346(2), b = 12.412(2), and c = 11.937(2) Å; β = 109.39(3)°	a = 10.415(2), b = 10.485(2), and c = 13.702(3) Å
Volume (Å^3)	1445.9(4)	1496.3(5)
Z, calculated density (Mg/m^3)	4, 1.279	4, 1.307
Absorption coefficient (mm^{-1})	1.932	0.345
F(000)	600	632
Crystal size (mm)	0.2×0.4×0.5	0.4×0.4×0.6
Θ Range for data collection (deg)	3.93–79.94	3.13–29.29
Index ranges	$0 \le h \le 11$, $0 \le k \le 14$, $-14 \le l \le 11$	$-14 \le h \le 13$, $-14 \le k \le 14$, $-18 \le l \le 12$
Reflections collected/unique	3164/3023 [R(int) = 0.0176]	9866/3771 [R(int) = 0.0233]
Refinement method	Full-matrix least-squares on F^2	Full-matrix least-squares on F^2
Data/restraints/parameters	3023/1/344	3771/0/261
Goodness-of-fit on F^2	1.073	1.090
Final R indices [$I > 2\sigma(I)$]	$R1$ = 0.0355, $wR2$ = 0.1015	$R1$ = 0.0369, $wR2$ = 0.1019
R indices (all data)	$R1$ = 0.0389, $wR2$ = 0.1040	$R1$ = 0.0415, $wR2$ = 0.1060
Absolute structure parameter	0.01(2)	−0.01(7)
Extinction coefficient	0.0127(9)	0.014(3)
Largest diff. peak and hole (e Å^{-3})	0.221 and −0.233	0.285 and −0.228