2,12′-BIS-HAMAZULENYL FROM *Ajania fruticulosa* ESSENTIAL OIL

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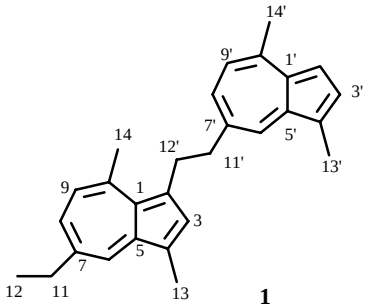
A new bisazulene, the structure of which was established using x-ray structure analysis and PMR and ^{13}C NMR spectra, was isolated from essential oil of Ajania fruticulosa *obtained by steam distillation.*

Key words: *Ajania fruticulosa*, 2,12′-bis-hamazulenyl, XSA, ^{13}C NMR, PMR.

The genus *Ajania* Poljak (Asteraceae) in Russia and adjacent states numbers 10 species [1], the most common of which is *Ajania fruticulosa*.

Known flavonoids and phenolcarboxylic acids [2, 3], a new germacranolide ajanolide [3], and three new guaianolides [4-6] have been observed in the aerial part of this plant. Steam distillation isolated the dark blue essential oil [7], the color of which is due to the presence of hamazulene [8], the content of which in the oil increases greatly with increasing time of distillation [7].

During chromatography of the essential oil over aluminum oxide with elution by petroleum ether, two dark blue bands form on the column. The upper of these contains hamazulene; the lower, as it turns out, corresponds to a new crystalline dark blue compound with mp 136-138°C. According to high-resolution mass spectrometry, it has empirical formula $C_{28}H_{30}$. It can be assumed from the color in combination with the empirical formula that the compound is some sort of azulene dimer. We resolved this issue by performing an x-ray structure analysis (XSA) and found that the compound is in fact a dimer of hamazulene and has the structure 2,12′-bis-hamazulenyl (**1**). Figure 1 shows the structure.



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The azulene fragments of **1** are planar with a mean-square deviation of the atoms of 0.010 and 0.004 Å for C1-C10 and C1′-C10′, respectively (Fig. 1). The interplanar angle between these fragments is 2.3(5)°. The ethyl bridge is out of the planes of the azulene fragments [torsion angles C3-C2-C12′-C11′ -88(1)° and C12′-C11′-C7′-C8′ 87(1)°]. The bonds lengths are the same within experimental uncertainty as those in the structurally similar synthetic dimers (*E*)-1,2-bis(3-guaiazulenyl)ethylene [8] and (1*R*,2*S*)-1,2-bis(4-(methoxycarbonyl)phenyl)-1,2-bis(3-guaiazulenyl)ethane [9]. The XSA of a specially prepared hamazulene derivative has been reported [10]. The molecules in the crystal are stacked along the *b* axis. However, the large (4.948 Å) distances between the centers of the molecules precludes a π-stacking interaction.

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TABLE 1. ^{13}C NMR and PMR Spectra of **1** (C_6D_6, δ-scale, J/Hz, 0 = TMS)

Atom	C_i	H_i	Atom	C_i	H_i
1	133.14 s	-	1′	138.04 s	-
2	138.63 s	7.30 br.d (J = 2.0)	2′	113.67 d	7.34 d (J = 4.0)
3	140.57 d	7.43 s	3′	136.72 d	7.67 br.d (J = 4.0)
4	136.91 s*	-	4′	136.91 s*	-
5	124.29 s	-	5′	125.48 s	-
6	134.66 d	8.05 br.d (J = 2.0)	6′	135.33 d	8.13 br.d (J = 1.0)
7	134.54 s	-	7′	133.70 s	-
8	135.33 s	7.08 dd (J = 10.5; 2.0)	8′	136.95 d	7.25 dd (J = 10.5; 2)
9	126.26 d	6.64 d (J = 10.5)	9′	124.90 d	6.78 dd (J = 10.5)
10	145.07 s	-	10′	144.24 s	-
11	33.42 t	2.54 k (J = 8.0)	11′	44.80 t	3.17 distort. t (J = 8)
12	17.32 k	1.21 t (J = 8.0)	12′	35.56 t	3.61 distort. t (J = 8)
13	13.02 k	2.55 (3H) br.s**	13′	12.92 k	2.55 (3H) br.s**
14	26.97 k	2.75 (3H) br.s	14′	24.06 k	2.60 (3H) br.s

*Signals for C-4 and C-4′ overlap, **signals for 3H-13 and 3H-13′ differ by about 0.004 ppm.

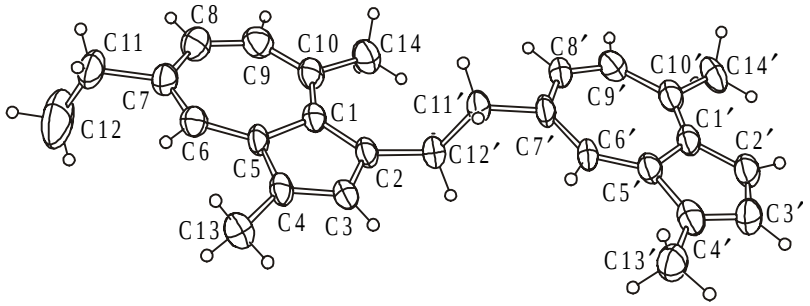

Fig. 1. Molecular structure of 2,12′-bis-hamazulenyl.

Signals in the PMR and ^{13}C NMR spectra of **1** (Table 1) were assigned using COSY $^1H—^1H$, $^{13}C—^1H$ and COLOC $^{13}C—^1H$ two-dimensional (2D) spectra. The most important observed cross peaks in the 2D COLOC spectrum were C-2/H-3, C-6/H-11, C-6′/H-11′, C-7/H-12, C-7′/H-11′, C-9/H-14, C-9′/H-14′, C-10/H-14, and C-10′/H-14′.

Natural guaiazulene and its biologically active dimers have also been found in marine coral of the genus *Gorgonaceae*, where they impart color to these marine organisms [11]. Dimeric guaianolids are encountered in plants and are possible precursors of dimeric hamazulene **1** and its analogs that have not yet been prepared [12].

EXPERIMENTAL

IR spectra were recorded on a Vector 22 instrument. UV spectra were recorded on an HP 8453 spectrophotometer; NMR spectra, on a Bruker DRX-500 spectrometer (working frequency 500.13 MHz for ^1H, 125.76 MHz for ^{13}C). The high-resolution mass spectrum (EI, 70 eV) was obtained in a Finnigan MAT 8200 instrument.

Raw material of the leafy part of *Ajania fruticulose* (Ledeb.) Poljak growing near the village Dogolan of Eastern Kazakhstan District was collected during budding at the beginning of August 2004. Essential oil was obtained by steam distillation in a Clevenger apparatus over 3 h. The yield of oil was 0.70% calculated for air-dried raw material.

Compound 1. A weighed portion of essential oil (34.0 g) was chromatographed over neutral Al_2O_3 with elution by petroleum ether. A colorless mixture of components eluted first and then hamazulene (dark blue oil, 12.1 g) and finally dark blue crystals of **1** (0.10 g), mp 136-138°C, $C_{28}H_{30}$.

UV spectrum ($CHCl_3$, λ_{max}, nm): 247, 293, 308, 355, 372, 657 (log ε 4.62, 4.79, 4.56, 4.04, 3.00, 2.12).

IR spectrum (KBr, ν, cm^{-1}): 2960, 2923, 2858 (C–H), 1546, 1520, 1422, 1368, 962, 864, 806, 773, 711.

Mass spectrum (EI, 70 eV, *m*/*z*, I_{rel}, %): 366 (42) $[M]^+$, 189 (67), 177 (100), 181 (32), 180 (15), 169 (23), 167 (42), 165 (27), 152 (24), 141 (15).

X-ray structure analysis of 1 was carried out on a Bruker P4 diffractometer (Mo Kα-radiation, graphite monochromator, ω-scanning) at room temperature. Compound **1** crystallizes as very thin plates of poor quality. Therefore, data were collected in the range $2\theta < 40°$. The crystallographic parameters are monoclinic, $a = 12.988(5)$, $b = 4.948(4)$, $c = 33.466(12)$ Å, $\beta = 94.47(2)°$, V = 2144.1(19) $Å^3$, space group $P2_1/n$, $C_{28}H_{30}$, $Z = 4$, $D_c = 1.135$ g/cm^3, $\mu = 0.064$ mm^{-1}, crystal size 1.1×0.3×0.02 mm. The structure was solved by direct methods using the program SHELXS-97 and refined by anisotropic and isotropic least-squares methods using the program SHELXS-97. Positions of H atoms were calculated geometrically. The final R factors were $wR_2 = 0.4288$ and S = 1.141 for 1985 independent reflections (R = 0.1268 for 1063 reflections with $I > 2\sigma$). Crystallographic data for **1** and parameters of the x-ray experiment were deposited in the Cambridge Crystallographic Data Center (No. CCDC 299273).

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