1-ACYL- AND 1,2-DIHYDRO-1*H*(ACYL)DEOXYVASICINONES. SYNTHESIS AND CHEMICAL TRANSFORMATIONS

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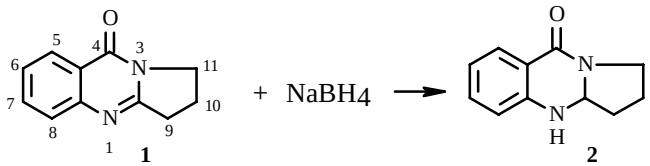
*1-Acyl- and 1,2-dihydro-1*H*(methyl, acyl)deoxyvasicinones were synthesized. Their PMR and ^{13}C NMR spectra were investigated. The chemical shifts and SSCC were determined. 1-Acyl derivatives were produced by acylation of 1,2-dihydrodeoxyvascinone with caprylyl- and chloroacetylchlorides. It was shown that the Cl atom of 1-chloroacetyldeoxyvasicinone was labile and underwent nucleophilic substitution by amines. In contrast with this, it reacted with cyanide, hydroselenide, methoxide, phenoxide, and anions of compounds with an activated methylene group in a completely different direction to cleave the chloroacetyl group and form 1,2-dihydrodeoxyvasicinone. It was found that addition of 1,2-dihydrodeoxyvasicinone to phenylacetylene occurred regio- and stereoselectively to form the cis-isomer of 1-(2-phenylvinyl)-1,2-dihydrodeoxyvasicinone.*

Key words: deoxyvasicinone, 1*H*(acyl)-1,2-dihydrodeoxyvasicinone salts, PMR, ^{13}C NMR, regioselectivity, phenylacetylene, nucleophilic substitution, addition.

We recently found that deoxyvasicinone reacted with acetylbromide and benzoyl- and *p*-nitrobenzoylchlorides to form salts of *N*-acyldeoxyvasicinone [1-3], which turned out to be effective acylating agents for aliphatic and aromatic primary and secondary amines [2] and for the natural compounds cytisine and α- and β-amino acids [3]. On the other hand, we discovered that the N=C bond of deoxyvasicinone, its seven-membered homolog 2,3-pentamethylene-3,4-dihydroquinazol-4-one, and their analogs is reduced selectively by $NaBH_4$ [5-7], in contrast with reduction by zinc in HCl or HOAc and also by $LiAlH_4$ [4]. However, the structural features of the products from reduction of the N=C bond were insufficiently elucidated in these studies, in particular, of 1,2-dihydrodeoxyvasicinone and its transformation products [5].

In continuation of our research on chemical transformations of tricyclic quinazoline alkaloids, we reduced deoxyvasicinone (**1**) with $NaBH_4$ in alcohol [5] to produce 1,2-dihydrodeoxyvasicinone (**2**) in good yield (82%).



1 **2**

The products of chemical transformations of **1** in this study were monitored by NMR spectroscopy. The general characteristics of the PMR spectrum of deoxyvasicinone have been published [8]. Herein both the PMR and the ^{13}C NMR spectra of certain derivatives of **1** are investigated in detail.

Table 1 gives the NMR spectra of **2**.

The three-dimensional structure of **1** is practically planar. Only C-10 deviates from the common plane of the molecule (the five-membered ring has the C-10 envelope conformation). Reduction of the N1=C2 double bond changes the conformation of the saturated six-membered ring to a C2 chair; of the five-membered ring, a C9 envelope. The orientation of the two H11 protons is almost the same relative to the average plane of the molecule.

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TABLE 1. NMR Spectra of **2**, CD_3OD, H_0 = 400 MHz, 0 = TMS

Atom	^{1}H chemical shifts, ppm	Spin-spin coupling constants, Hz	^{13}C chemical shifts, ppm
2	4.05	5.73 (H-9), 7.26 (H-9′)	71.34
4			164.70
4a			118.31
5	7.69	7.82 (H-6), 1.59 (H-7), 0.49 (H-8)	128.58
6	6.80	7.82 (H-5), 7.26 (H-7), 1.09 (H-8)	119.97
7	7.28	1.59 (H-5), 7.26 (H-6), 8.12 (H-8)	134.49
8	6.75	0.49 (H-5), 1.09 (H-6), 8.12 (H-7)	116.06
8a			150.22
9	2.35	ΣSSCC = 23.8	34.01
9′	1.90-2.10	Complex 3H multiplet	
10	1.90-2.10	"-"	22.67
10′	1.90-2.10	"-"	
11	3.69	12.36 (H_a-11), 7.93 (H_a-10), 7.93 (H_e-10)	45.40
11′	3.58	12.36 (H_e-11), 8.48 (H_a-10), 3.60 (H_e-10)	

The spin-coupled partner is given in parentheses next to the SSCC.

Dihedral angles C4–N3–C11–H11 and C4–N3–C11–H11′ are 51° and 72° so that the polarizing and inductive effects of the carbonyl and unshared electron pair of N3 on both H11 protons are very similar. The difference in the chemical shifts of these protons is only 0.11 ppm. However, this is entirely adequate to observe reliably and separately the resonances of these geminal protons.

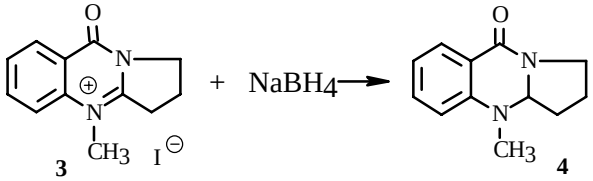
The greatest changes in the orientation of geminal protons occurred for the H9 protons. Dihedral angles H2–C2–C9–H9 and H2–C2–C9–H9′ are 45° and 167°. The *cis*- and *trans*-SSCC of the H2 protons with the H9 protons are 5.73 and 7.26 Hz, respectively. However, the H9 multiplet at 3.35 ppm forms a very complex unresolvable multiplet for which only the total of all its SSCC can be estimated, 23.8 Hz. This is typical of an equatorial proton. The axial H9′ proton resonates at 1.90-2.10 ppm and unfortunately overlaps another two very complex multiplets of the H10 protons.

The resonances of the aromatic protons form a very clear pattern of four separate resonances with three resolved SSCC in each of them. Constant J(H5,H8) = 0.49 Hz was detected through five bonds. Chemical shifts of H6 and H8 are smaller than those of H5 and H7, which agrees well with the rule of alternation in an aromatic system and the effect of the carbonyl group.

The PMR spectrum of **2** shows a distinct temperature dependence even in the range 20-55°C. On heating, the individual lines of the multiplets narrow and become better resolved. This may indicate the presence in **2** of several conformers with a small transition barrier between them. Heating by 30-35°C above room temperature gives the average resonances and the spectra become simpler.

The ^{13}C NMR spectrum of **2** is typical of a quinazolone system [4]. The aromatic part of the spectrum contains seven resonances, one from a carbonyl C atom and six from the aromatic ring. Assigning resonances of the quarternary C atoms is not difficult because of the clear influence of N-1 on the resonance of C-8a (150.22 ppm). The rule of alternation of electron density and, therefore, nuclear shielding, is clearly visible in resonances of the tertiary aromatic C atoms, like in the PMR spectra (Table 1). Assignments of resonances of the phenyl C atoms of **2** is also in good agreement with the literature for analogous bicyclic systems [9-11]. Resonances of C atoms of the saturated part of the molecule have very characteristic increments in chemical shifts because of the two N atoms and are easily assigned (Table 1).

Changes in the PMR and ^{13}C NMR spectra upon adding substituents in the 1-position of **2** are interesting. It was shown earlier that reduction of **1** methyl iodide (**3**) by $NaBH_4$ gives 1-methyl-1,2-dihydrodeoxyvasicinone (**4**) [5].



3 **4**

TABLE 2. NMR Spectra of **4**, CD_3OD, H_0 = 400 MHz, 0 = TMS

Atom	^{1}H chemical shifts, ppm	Spin-spin coupling constants, Hz	^{13}C chemical shifts, ppm
2	4.61	4.97 (H-9_e), 8.91 (H-9_a)	76.49
4			164.25
4a			119.62
5	7.77	7.66 (H-6), 1.70 (H-7), 0.51 (H-8)	128.68
6	6.88	7.66 (H-5), 7.33 (H-7), 1.01 (H-8)	120.11
7	7.42	1.70 (H-5), 7.33 (H-6), 8.34 (H-8)	135.00
8	6.86	0.51 (H-5), 1.01 (H-6), 8.34 (H-7)	113.60
8a			151.53
9e	2.46	10.62 (H-9_a), 5.38 (H-10_a), 4.97 (H-2), 0.40 (H-11_a)	34.34
9a	2.02	10.62 (H-9_e), 8.91 (H-2), 6.42 (H-10_e), 0.40 (H-11_a)	
10e	2.10	12.00 (H-10_a), 7.30 (H-11_a), 6.42 (H-9_a), 1.05 (H-11_e)	22.08
10a	1.93	12.00 (H-10_e), 12.00 (H-11_a), 10.08 (H-11_e), 5.38 (H-9_e)	
11e	3.72	12.12 (H-11_a), 10.08 (H-10_a), 1.05 (H-10_e)	45.83
11a	3.63	12.12 (H-11_e), 12.00 (H-10_a), 7.30 (H-10_e), 0.40 (H-9_e), 0.40 (H-9_a)	
N-Me	2.79		33.71

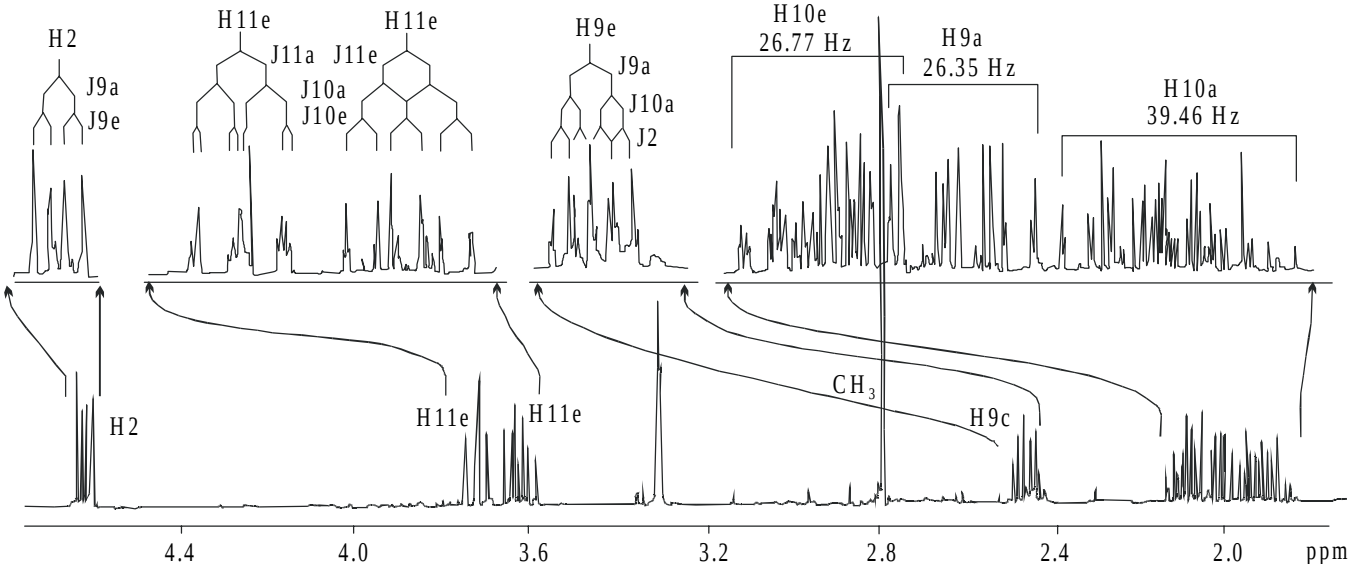


Fig. 1. PMR spectrum of the alkane part of **4** in CD_3OD. The total width of the multiplet is given for H9a, H10e, and H10a.

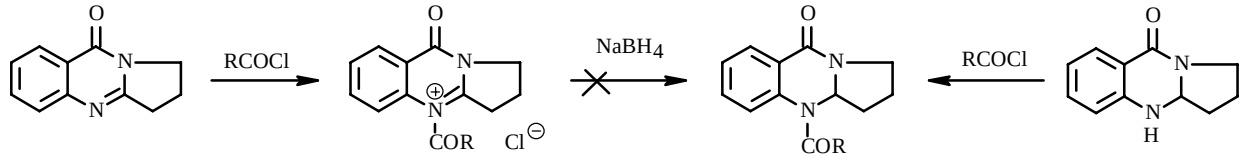
The PMR spectrum of **4** (methylated analog of 1,2-dihydrodeoxyvasicin-2-one) in CD_3OD is naturally very similar to that of **2** itself. The most characteristic differences in the spectrum are the appearance of a resonance for the methyl (2.79 ppm) and a weak-field shift (by 0.56 ppm) of the resonance for H-2. The presence of a relatively bulky substituent on N1 stabilizes the conformation of the saturated part of the molecule. The resolution of the PMR spectrum improves substantially. Whereas resonances of separate protons up to three SSCC could be observed in the spectrum of **2**, those for four SSCC and even five SSCC for the H-11a protons could be reproduced in the saturated part of its methylated analog. The methyl group gives a poorly resolved SSCC with H-2 (~0.2 Hz) and possibly with H-8 (~0.1 Hz). In these instances SSCC were measured from the change of width of separate individual lines in resonances of H-2 and H-8. Furthermore, the methyl exerts an Overhauser effect on resonances of H-8 (13%), H-2 (4.5%), and both H9 protons (~3%). Table 2 lists the parameters of the NMR spectra of **4**.

The individual multiplets of the H-2 protons and both H-11 and H-9a become regular and close to first order (Fig. 1). The high resolution of these resonances enables practically all SSCC for this spin system to be determined. Three overlapping resonances in **2** (H-9a, H-10a, and H-10e), although forming as before a single very broad multiplet, nevertheless can be separated into individual multiplets. This turned out to be sufficient to determine the remaining three SSCC between these protons. Thus, all chemical shifts and practically all SSCC for **4** could be reproduced.

The ^{13}C NMR spectrum of **4** agreed well with that of nonmethylated **2** and with characteristic features of quinazolone derivatives.

Acyl groups were added to **1** and **2** by acylation. It was shown earlier that **1** reacts with benzoylchloride to form 1-benzoyldeoxyvasicinone chloride (**5a**) [3, 6]. We carried out this reaction with caprylylchloride in order to determine if chlorides of aliphatic acids could be used.

Compound **1** also reacts with acetylbromide to form 1-acetyldeoxyvasicinone bromide (**5c**) [6]. As it turned out, **1** reacts with caprylylchloride to give salt **5b** in good yield [6].



1 **5a,b,c** **6a,b, 7** **2**

5a, 6a: R = C_6H_5; **5b, 6b:** R = C_7H_{15}; **5c:** R = CH_3; **7:** R = CH_2Cl

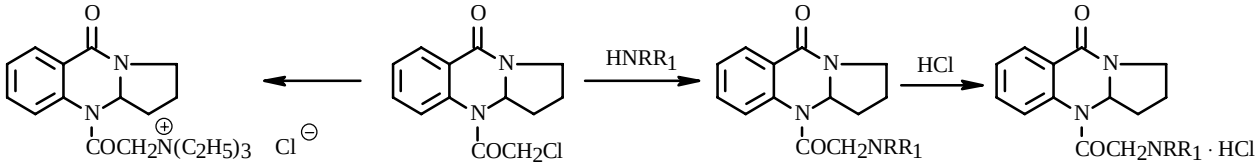
The ability to reduce the quaternary ^{+}N=C2 bond of **1** methyl iodide (**3**) with $NaBH_4$ to give **4** [5] suggested that salt **5** might also be reduced by it. However, the reaction of **5a** and **5b** with $NaBH_4$ with heating in alcohol cleaved the acyl group to form **2**.

Compounds **6a** and **6b** were prepared by acylation of **2** with benzoyl- or caprylylchlorides in the presence of Et_3N.

Acylation of 1,2-dihydrodeoxyvasicinone by chloroacetylchloride was interesting from two points of view; first, for studying the relative reactivity of the acylating agents and; second, because of the presence in 1-chloroacetyl-1,2-dihydrodeoxyvasicinone of a labile Cl atom that might undergo nucleophilic substitution. Furthermore, the expected compounds were interesting as potential biologically active compounds. The reaction was carried out in benzene in the presence of Et_3N (for binding the released HCl) and produced 1-chloroacetyl-1,2-dihydrodeoxyvasicinone (**7**) in high yield (80%).

The Cl atom in compounds with electron-accepting substituents (CO, COO, SO_3H, NO_2, N–C=N, and others) in the α-position to a methylene is known to be labile and can undergo nucleophilic substitution reactions. Compound **7** that was synthesized by us is such a compound, in particular, a derivative of α-chloroacetamide. We decided to study its reactions with amines, alcohols, phenols, hydroselenides, and compounds with activated methylenes because these are nucleophiles and should react.

Compound **7** reacted with various amines. The reactions occurred under various conditions depending on the nature and basicity of the amines.



16 **7** **8 - 11** **12 - 15**

8, 12: R = R_1 = CH_3; **9, 13:** R = R_1 = C_2H_5; **10, 14:** R + R_1 = $(CH_2)_5$

11, 15: R + R_1 = $(CH_2)_2O(CH_2)_2$

We used aliphatic (dimethyl- and diethylamine) and heterocyclic (piperidine, morpholine) amines in the reactions, which proceeded readily with heating the reagents in a 1:1 ratio (**7**:amine) in absolute benzene for 4 h.

Compound **7** reacted with Et_3N to give quaternary salt **16**.

The synthesized 1-dialkyl(hetaryl)aminoacetyl-1,2-dihydrodeoxyvasicinones **8-11** crystallized well from organic solvents. They were very soluble in alcohol, acetone, benzene, and other solvents and poorly soluble in water. They could be recrystallized from hexane. They were strong bases and easily formed hydrochlorides **12-15**. These, like **16**, were very soluble in water and alcohol and slightly soluble in other organic solvents.

The structures of the prepared compounds were confirmed by IR, PMR, and mass spectra.

The IR spectra of **8-11** contained absorption bands for carbonyl at 1675-1685 cm^{-1} (νCO), typical of quinazol-4-ones [4, 8]; at 1650-1659 cm^{-1} (νN–CO); and at 1603-1606 cm^{-1} (νCH=CH).

TABLE 3. PMR Spectra of **2** and 1-Dialkyl(hetaryl)aminoacetyl-1,2-dihydrodeoxyvasicinones in $CDCl_3$

Compound	C atom									
	2	5	6	7	8	9	9a,10e,a	11e,a	CO-CH_2	NRR_1
2	5.07	7.95	6.87	7.32	6.69	2.43	1.77-2.32	3.57-3.97		NH 4.47
7	5.12	8.09	7.39	7.52	7.24	2.87	1.83-2.70	3.57-3.82	4.19, 4.26	
9	5.12	8.05	7.39	7.47	7.45	2.87	1.67-2.57	3.57-3.77	3.42, 3.42	Eth 2.44, 0.92
10	5.12	8.06	7.21-7.44	7.47	7.21-7.44	2.82	1.72-2.57	3.57-3.77	3.27, 3.27	α 2.37, β,γ 1.42
11	5.12	8.05	7.20-7.57*			2.78	1.72-2.67	3.47-3.72	3.26, 3.30	M-n 2.52, 3.67

*Values given for the 6th, 7th, and 8th C atoms.
M-n [Morpholine].

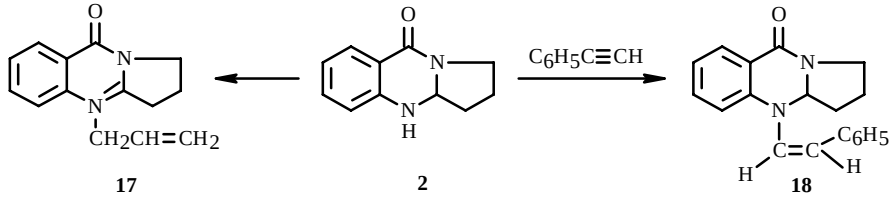
PMR spectra of the prepared derivatives had somewhat different chemical shifts than those of the framework molecules. The greatest shift in the position of the resonances compared with those of **2** in $CDCl_3$ (Table 3) were observed for aromatic protons H-6 and H-8 (weak-field shift of ~0.5 ppm) and for equatorial proton H-9. The shifts of the remaining resonances were considered insignificant. Apparently the shifts of the aromatic protons were due to conjugation with the carbonyl. According to the redistribution of charge around the aromatic system, the changes of protons H-6 and H-8 were rather large whereas those of H-5 and H-7 were much smaller. The change of equatorial proton H-9 was due most probably to the inductive effect of the substituents in **7**-**11**. The nature of the multiplicity in all spectra was almost unchanged.

Mass spectra of the compounds showed weak (10-20%) peaks for the molecular ions. Further fragmentation of $[M]^+$ led to loss of a cyclopentane ring or an aminoacetyl group.

It seemed interesting to study substitution of the Cl in 1-chloroacetyl-1,2-dihydro-**1** (**7**) by other nucleophilic reagents (cyanide, hydroselenide, methoxide, phenoxide, and anions of compounds with activated methylenes such as malonic, acetoacetic, and cyanoacetic esters, acetylacetone, etc.). However, in all instances it turned out that the reaction was accompanied by cleavage of the chloroacetyl group and formation of 1,2-dihydrodeoxyvasicinone (**2**).

Methylation of **2** by methyliodide in the presence of NaH in DMF is known to occur at N-1 [5]. Partial dehydration of 1,2-dihydrodeoxyvasicinone and its seven-membered analog to **1** and its homolog occurred. We studied alkylation of **2** with allylbromide. Formation of 1-allyl-1,2-dihydrodeoxyvasicinone and its isomerization products, the 1-*cis*- and 1-*trans*-propen-1-yl derivatives, was expected. The possibility of such isomerization was demonstrated using 9-allylcarbazole [12] and 10-allylphenothiazine [13] as examples. Performing the reaction under methylation conditions [5] led to formation of the normal allylation product (**17**). In addition, starting material and its dehydrogenation product (**1**) remained in the reaction mixture. Thus, dehydrogenation is a general reaction of **2**.

Possible addition of **2** to phenylacetylene was studied by carrying out the reaction in superbase (DMSO + KOH). It proceeded regioselectively to form mainly 1-*cis*-(2-phenylvinyl)-1,2-dihydrodeoxyvasicinone (**18**).



17 **2** **18**

The structure of **18** was confirmed by IR and PMR spectra. Its IR spectrum contained absorption bands for carbonyl, double bonds of the benzene ring and others, and bands at 759 and 695 cm^{-1}, typical of *cis*-ethenyl.

The PMR spectrum of protons in the sidechain double bond appeared as two doublets at 5.86 (1H, d, J = 9, α-H) and 6.30 (1H, d, J = 9, β-H). The SSCC of 9.0 Hz indicated that the protons of the double bond were in the *cis*-position. Thus, addition to **2** of phenylacetylene occurred regio- and stereoselectively with formation exclusively of *cis*-1-(2-phenylvinyl)-**2** (**18**).

Similar regioselectivity was observed for nucleophilic addition of phenothiazines to phenylacetylene [14] and isomerization of 10-allylphenothiazine into the *cis*-propenyl derivative [13].

It is known that *cis*-10-(2-phenylvinyl)- and 10-alkenylphenylthiazines are isomerized into the corresponding *trans*-isomers [13, 14].

We attempted to carry out the isomerization of *cis*-**17** into the *trans*-form by heating it at 100-110°C for 3 h. However, such isomerization did not occur. The *cis*-form **18** remained unchanged.

EXPERIMENTAL

IR spectra were recorded on a Perkin—Elmer Model 2000 Fourier IR spectrometer in pressed KBr disks. Mass spectra were recorded in MX-1310 and MS25RS (Kratos) spectrometers at ionizing potential 70 eV, source temperature 250°C, direct sample introduction at 120°C, and accelerating potential 4 kV. NMR spectra were recorded on a UNITY-400+ spectrometer at operating frequency 400 MHz for ^{1}H and 100 MHz for ^{13}C. Samples were prepared in CD_3OD with TMS internal standard (0 ppm). Spectra (except variable temperature experiments with **2**) were recorded at room temperature. Highly accurate measurements of SSCC were obtained by setting the detection time for signal decay by free induction to 8 s, using a digital filter before Fourier transformation to increase resolution, and refining all resonances in PMR spectra using the LAME integration program to two decimal places accuracy. Deoxyvasicinone was prepared by the literature method [8]. 1,2-Dihydrodeoxyvasicinone was synthesized as before [5]. Salts of *N*-acyldeoxyvasicinone **5a** and **b** were prepared by the literature methods [3, 6].

1-Caprylyl-1,2-dihydrodeoxyvasicinone (6b). A stirred solution of 1,2-dihydrodeoxyvasicinone (0.5 g, 2.7 mmol) in absolute benzene (30 mL) was treated with Et_3N (0.37 mL, 2.7 mmol) and dropwise with a solution of caprylylchloride (0.45 mL, 2.7 mmol) in the same solvent (3 mL). The reactoin mixture was stirred at room temperature for 1 h, then at 85-90°C for 1.5 h, cooled, treated with water (30 mL), and transferred to a separatory funnel. The organic layer was separated, washed with water (2×), and dried over Na_2SO_4. Solvent was distilled off. The solid was recrystallized from hexane to afford **6b** (0.5 g, 60%), mp 190-192°C, R_f 0.73 (Silufol, $CHCl_3$:CH_3OH, 10:1).

1-Chloroacetyl-1,2-dihydrodeoxyvasicinone (7) 1,2-Dihydrodeoxyvasicinone (10 g, 5.3 mmol) was placed in a three-necked flask equipped with a mechanical stirrer, dropping funnel, and reflux condenser; dissolved with stirring in absolute benzene (100 mL); treated first with Et_3N (5 mL, 5.3 mmol) and then dropwise through the dropping funnel with a solution of chloroacetylchloride (15 mL, 0.2 mmol) in absolute benzene (20 mL). The reaction mixture was heated on a water bath with stirring and refluxing for 4 h and cooled. The resulting precipitate was filtered off. The residue was treated with water. The resulting crystals were separated, dried, and recrystallized from hexane. Yield 14.2 g (80%), mp 141-142°C, R_f 0.70 (Silufol, $CHCl_3$:CH_3OH, 10:1).

IR spectrum (cm^{-1}): 1688, 1661 (ν_{CO}), 1606, 1580, 1482 ($\nu_{CH=CH}$). Mass spectrum (%): 264/266 (4) $[M]^+$, 263/265 (2) $[M - 1]^+$, 230 (89), 229 (68), 187 (23), 186 (11), 160 (5), 146 (100).

1-Dimethylaminoacetyl-1,2-dihydrodeoxyvasicinone (8). A solution of 1-chloroacetyl-**2** (1.5 g, 5 mmol) in alcohol (30 mL) was treated with aqueous dimethylamine (2.27 mL, 34 mmol, 33%), heated on a water bath for 4 h, diluted with water (30 mL), extracted with $CHCl_3$ (3×), and dried over $MgSO_4$. The solvent was distilled off. The solid was recrystallized from hexane. Yield 1 g (65%), mp 123-124°C, R_f 0.70 (Silufol, $CHCl_3$:CH_3OH, 10:1).

IR spectrum (cm^{-1}): 1688, 1661 (ν_{CO}), 1606, 1580, 1482 ($\nu_{CH=CH}$). PMR spectrum ($CDCl_3$, δ, ppm): 3.50 (2H, s, N–CH_2), 3.56-3.70 (2H, CH_2–11, m), 1.65-1.65 (4H, m, CH_2CH_2), 3.60 [6H, s, $N(CH_3)_2$], 5.12 (1H, q, H-2), 7.22-7.50 (3H, m), 7.91-8.05 (1H, dd, H-5). Mass spectrum (%): 273 (20) $[M]^+$, 272 (8) $[M - 1]^+$, 271 (14) $[M - 2]^+$, 229 (23), 215 (8), 214 (15), 188 (100), 187 (18), 186 (15), 161 (95), 147 (40), 119 (20).

1-Diethylaminoacetyl-1,2-dihydrodeoxyvasicinone (9). A mixture of 1-chloroacetyl-1,2-dihydrodeoxyvasicinone (1.5 g, 5.7 mmol) and diethylamine (1.8 mL, 17 mmol) in benzene (30 mL) was refluxed for 4 h, cooled, and thoroughly washed with water. The organic layer was separated and dried over $MgSO_4$. The solvent was distilled off. The solid was recrystallized from hexane. Yield 1.13 g (67%), mp 95-96°C, R_f 0.76 (Silufol, $CHCl_3$:CH_3OH, 10:1).

IR spectrum (cm^{-1}): 1685, 1659 (ν_{CO}), 1603, 1578, 1480 ($\nu_{CH=CH}$).

1-Piperidinoacetyl-1,2-dihydrodeoxyvasicinone (10) was prepared analogously to that described above from **7** (1.5 g, 11 mmol) and piperidine (1.05 mL, 11 mmol) in benzene (30 mL) to afford the product (1.2 g, 68%), mp 93-94°C, R_f 0.75 (Silufol, $CHCl_3$:CH_3OH, 10:1).

IR spectrum (cm^{-1}): 1676, 1650 (ν_{CO}), 1607, 1578, 1484 ($\nu_{CH=CH}$).

1-Morpholinoacetyl-1,2-dihydrodeoxyvasicinone (11) was prepared from **7** (1.5 g, 5.7 mmol) and morpholine (1.57 mL, 18 mmol) in benzene (30 mL) analogously to the preparation of **8** to afford the product (1.23 g, 69%), mp 151-152°C (hexane), R_f 0.72 (Silufol, $CHCl_3$:CH_3OH, 10:1).

IR spectrum (cm^{-1}): 1678, 1656 (ν_{CO}), 1608, 1577, 1472 ($\nu_{CH=CH}$). Mass spectrum (%): 315 (10) $[M]^+$, 314 (3) $[M - 1]^+$, 313 (4) $[M - 2]^+$, 285 (17), 245 (16), 229 (27), 228 (17), 215 (16), 160 (17), 146 (17), 146 (100), 132 (22), 119 (17).

Dimethylaminoacetyl-1,2-dihydrodeoxyvasicinone Hydrochloride (12). Compound **8** (500 mg) was dissolved in absolute Et_2O (10 mL) and saturated with gaseous HCl until crystals formed to give **12** (550 mg, 97%), mp >300°C (dec.).

Salts **13-15** were prepared analogously and decomposed at >300°C.

1-Triethylammoniumacetyl-1,2-dihydrodeoxyvasicinone Chloride (16). 1-Chloroacetyl-1,2-dihydrodeoxyvasicinone (1.5 g, 5.7 mmol) and Et_3N (0.8 mL, 5.7 mmol) in benzene (30 mL) were left at room temperature for 8 h. The resulting precipitate was separated. Yield 1.62 g (78%), mp 229-230°C, R_f 0.77 (Silufol, $CHCl_3$:CH_3OH, 10:1). IR spectrum (cm^{-1}): 1677, 1651 (ν_{CO}), 1606, 1579, 1470 ($\nu_{CH=CH}$).

Reaction of 7 with Cyanide. A solution of 1-chloroacetyl-1,2-dihydrodeoxyvasicinone (1 g, 3.8 mmol) in alcohol (100 mL) was treated with acetocyanhydride (1.0 ml, 12 mmol) and K_2CO_3 (0.38 g) in water (50 mL) and heated on a water bath for 24 h. The solid was filtered off. The solvent was distilled off. The solid was recrystallized from benzene to afford **2** (0.57 g, 80%), mp 180-181°C.

Reaction of 7 with Sodium Hydroselenide. A 250-mL four-necked flask equipped with a stirrer, reflux condenser, thermometer, and tube for adding He was charged with powdered selenium (0.41 g, 5.2 mmol) and water (25 mL), stirred for 20 min under He, treated with stirring in portions with $NaBH_4$ (0.39 g, 10.4 mmol), stirred for 20 min at room temperature and 1 h at 40°C, cooled to 20-22°C, treated dropwise with **7** (0.7 g, 2.6 mmol), stirred for 1 h at room temperature and 1 h at 90-95°C, and cooled. The resulting precipitate was filtered off. The filtrate was neutralized with acetic acid. The resulting solid was filtered off, washed with water, dried, and recrystallized from benzene to afford 1,2-dihydrodeoxyvasicinone (0.36 g, 73%), mp 179-180°C, R_f 0.79 (Silufol, $CHCl_3$:CH_3OH, 10:1).

Reaction of 7 with Sodium Methoxide. Sodium hydride (130 mg, 5.5 mmol) was added to absolute methanol (5 mL), treated with 1-chloroacetyl-1,2-dihydrodeoxyvasicinone (1.3 g, 5 mmol) in methanol (5 mL), left for 3 h, and diluted with water. The resulting precipitate was filtered off, washed with water, dried, and recrystallized from benzene to afford **2** (0.72 g, 76%), mp 179-180°C, R_f 0.78 (Silufol, $CHCl_3$:CH_3OH, 10:1).

Analogous results were obtained for the reaction of **2** with sodium phenoxide.

Reaction of 1-Chloroacetyl-1,2-dihydrodeoxyvasicinone with Sodium Malonic Ester. Metallic sodium (140 mg, 6 mmol) was placed in a flask with absolute alcohol (10 mL). The resulting solution of sodium ethoxide was treated with malonic ester (80 mg, 5 mmol), stirred at room temperature for 20 min, treated with **7** (1.3 g, 5 mmol) in absolute alcohol (5 mL), stirred for 2 h, and poured into water. The resulting precipitate was filtered off, washed with water, and dried to afford 1,2-dihydrodeoxyvacisinone (0.73 g, 78%), mp 179-180°C, R_f 0.76 (Silufol, $CHCl_3$:CH_3OH, 10:1).

The reactions with sodium acetoacetate (80% yield of **2**) and cyanoacetate esters (76% yield) and acetylacetone (80% yield) proceeded analogously.

Reduction of 5a with $NaBH_4$. A solution of $NaBH_4$ (0.28 g, 7.6 mmol) in alcohol (25 mL) was treated with *N*-benzoyldeoxyvasicinone chloride (0.5 g, 1 mmol) and heated on a water bath for 4 h. The alcohol was distilled off. The solid was treated with water (30 mL) and extracted with $CHCl_3$ (3 × 20 mL). The solvent was distilled off. The solid was recrystallized from hexane to afford **1** (0.2 g, 70%).

Reaction of **5c** with $NaBH_4$ to form **1** proceeded analogously.

Alkylation of 2 with Allylbromide. A solution of **2** (1 g, 5 mmol) in absolute DMF (25 mL) was treated with NaH (0.12 g, 5 mmol), stirred for 20 min, treated with allylbromide (0.44 mL, 5 mmol), heated and stirred on a water bath (70-80°C) for 1.5 h, cooled, diluted with water (40 mL), and extracted with benzene. The organic layer was dried over Na_2SO_4. The solvent was distilled off. The solid was recrystallized from hexane to afford **17** (1.4 g, 73%), mp 161-162°C, R_f 0.70 (Silufol, $CHCl_3$:CH_3OH, 10:1).

IR spectrum (cm^{-1}): 1660 (ν_{CO}), 1608, 1572, 1478 ($\nu_{CH=CH}$). Mass spectrum (%): 228 (73) $[M]^+$, 227 (46) $[M - 1]^+$, 187 (53) $[M - CH_2{=}CHCH_2]^+$, 186 (100) $[M - 42]^+$.

Addition of 2 to Phenylacetylene. A mixture of **2** (2.07 g, 11 mmol) and KOH (0.5 g) in DMSO (25 mL) was heated to 100°C, treated dropwise with phenylacetylene (2.4 mL, 22 mmol), held at this temperature for 2 h, cooled, diluted with water,

and extracted with $CHCl_3$. The organic layer was dried over Na_2SO_4. The solvent was evaporated. The solid was recrystallized from hexane to afford **18** (2.4 g, 78%), mp 191-192°C, R_f 0.76 (Silufol, $CHCl_3$:CH_3OH, 10:1).

IR spectrum (cm^{-1}): 1680 (ν_{CO}), 1605, 1581, 1477 ($\nu_{CH=CH}$), 759, 695 (CH=CH-*cis*). PMR spectrum (δ, ppm): 1.90-2.10 (2H, m, H-9), 2.46-2.72 (2H, m, H-10), 4.38-4.65 (2H, m, H-11), 6.75, 6.83, 6.47 (3H, m, H-8, H-7, H-6), 7.93-8.02 (1H, d, H-5), 7.35 (5H, s, Ar), 5.86-5.94 (1H, dd, H-2), 6.25-6.35 (1H, dd, Hβ, J = 9 Hz).

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