Sanguinones A and B, Blue Pyrroloquinoline Alkaloids from the Fruiting Bodies of the Mushroom *Mycena sanguinolenta*

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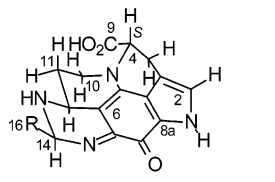
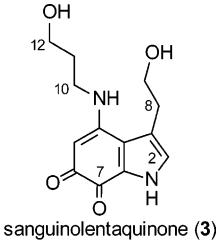
Two previously unknown blue alkaloid pigments, sanguinone A (**1**) and sanguinone B (**2**), and one new red indoloquinone alkaloid, sanguinolentaquinone (**3**), have been isolated from *Mycena sanguinolenta* fruiting bodies. In addition, decarboxydehydrosanguinone A (**4**) was identified as an oxidative decarboxylation artifact of **1**. The structures of these alkaloids have been established by 2D NMR and ESIMS methods. The absolute configurations of **1** and **2** were determined by comparison of their CD spectra with the CD spectrum of mycenarubin A (**5**), which we isolated recently from fruiting bodies of the mushroom *Mycena rosea*. The sanguinones are structurally related not only to the mycenarubins A (**5**) and B but also to a large number of marine alkaloids such as the discorhabdins.

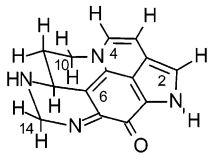
The terrestrial bleeding mycena, *Mycena sanguinolenta* (Alb. & Schw.: Fr.) Kummer (German name: Purpurschneidiger Bluthelmling), is a small mushroom that is widespread in the fir and beech forests of Europe and Northern America.[1] The fruiting bodies of the terrestrial bleeding mycena can easily be recognized since they contain a characteristic red latex, which is exuded if they are cut or bruised. The pigments responsible for the red color of the latex and the fruiting bodies of *M. sanguinolenta* have not as yet been investigated. Recently, we isolated red pyrroloquinoline alkaloids from the caps of the related species *M. rosea*.[2] This result led us to investigate whether the same pigments occur in both *Mycena* species. A comparative metabolic profiling by HPLC-UV of the fruiting bodies of *M. sanguinolenta* with those of *M. rosea* pointed to the presence of different, but structurally related alkaloids in *M. sanguinolenta*. In this paper we describe the isolation and structural elucidation of two blue alkaloids, which we have named sanguinone A (**1**) and sanguinone B (**2**), of one red alkaloid, which we have named sanguinolentaquinone (**3**), and of decomposition product **4** of **1**.



R = H: sanguinone A (**1**)
R = CH_3: sanguinone B (**2**)



sanguinolentaquinone (**3**)



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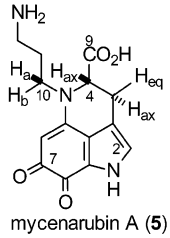

mycenarubin A (**5**)

Results and Discussion

Compounds **1** (5.2 mg), **2** (0.6 mg), and **3** (1.7 mg) were extracted from a sample of frozen fruiting bodies (100 g) of *M. sanguinolenta* with methanol at 25 °C and purified by HPLC on a preparative RP-18 column.

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The UV/vis spectrum of the blue main alkaloid sanguinone A (**1**) exhibited absorption maxima at λ 251, 376, and 578 nm. The absorption maxima were bathochromically shifted with respect to those of mycenarubin A (**5**), but exhibited similar extinction values, pointing to the presence of a pyrroloquinoline alkaloid core structure similar to that of **5**.[2] The HRESIMS of **1** showed an $[M + H]^+$ ion at *m/z* 299.1133 in agreement with the molecular formula $C_{15}H_{14}N_4O_3$. The ^1H NMR spectrum, recorded at 280 K in CD_3OD, exhibited 11 nonexchangeable protons. According to the HSQC correlations, the 15 signals in the ^{13}C NMR were assigned to four CH_2, three CH groups, and eight quaternary carbon atoms. The COSY spectrum revealed the presence of a CH_2CH_2CH moiety, an isolated CH_2 group with diasteretopically split protons, a CH_2CH fragment, and one aromatic proton. Both the CH_2CH fragment and the aromatic proton exhibited chemical shifts similar to the corresponding protons in **5**. Likewise, it was evident from the HMBC that the aromatic proton and the protons of the CH_2CH moiety had couplings to carbons with chemical shifts similar to those of the corresponding carbons in **5** (Table 1 and Figure 1). Therefore, **1** contains the same pyrroloquinoline moiety as **5**.

However, in contrast to **5**, the C-6 resonance (δ_C 96.4) was a quaternary carbon and a second aromatic CH moiety was missing. The resonance of C-7 (δ_C 148.6) differed considerably from the corresponding one (δ_C 180.8) in **5**. The chemical shift indicated that a nitrogen atom adjacent to the carbon at δ_C 148.6 replaced the corresponding carbonyl oxygen of **5**. The presence of an *ortho* iminoquinone moiety was also in agreement with a molecular formula that contained three oxygen and four nitrogen atoms.

A $^3J_{CH}$ correlation from the proton at C-4 (δ_H 4.27) to the CH_2 group at δ_C 49.8 (δ_H 3.85 and 3.68) in the HMBC indicated that the tertiary amine of sanguinone A was connected to a CH_2CH_2-CH fragment in **1**, instead of a $CH_2CH_2CH_2$ moiety. An HMBC correlation from the CH group at 3.78 (δ_C 46.7) to the quaternary carbon at δ_C 96.4 indicated that the CH_2CH_2CH moiety was connected to C-6. Hence, an additional six-membered ring is present in **1** compared to **5**. Analogously to **5**, a nitrogen is attached directly to the CH group, as revealed by its chemical shift of δ_C 46.7.

Thus, only the CH_2 group consisting of diastereotopic protons at δ_H 4.59 and 4.47 and the carbon at δ_C 58.8 had to be assigned to establish the complete molecular framework of **1**. One of the diastereotopic protons at δ_H 4.59 and 4.47 exhibited $^3J_{CH}$ correlations to the carbon at δ_C 148.6, while both of them exhibited $^3J_{CH}$ correlations to the carbon at δ_C 46.7 (Figure 1). Hence, this CH_2 group is directly attached to the nitrogen of the iminoquinone and to the nitrogen attached to the CH group of the CH_2CH_2CH fragment, forming an additional six-membered ring.

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Table 1. NMR Spectroscopic Data for Compounds **1**, **2**, and **5**

	sanguinone A (**1**)[a]		sanguinone B (**2**)[b]		mycenarubin A (**5**)[b]	
position	δ_C	δ_H (mult., *J* in Hz)	δ_C	δ_H (mult., *J* in Hz)	δ_C	δ_H
2	126.4, CH	7.05 (s)	128.1, CH	6.81 (s)	127.4, CH	6.85
2a	117.6, qC		117.6, qC		117.5, qC	
3	25.4, CH_2	3.49 (dd, 16.7, 1.0, H_{eq}) 3.28 (dd, 16.7, 7.6, H_{ax})	25.7, CH_2	3.04 (m)	25.5, CH_2	3.10 (H_{eq}) 3.05 (H_{ax})
4	67.4, CH	4.27 (dd, 7.6, 1.0, H_{ax})	67.3, CH	4.07 (m)	67.1, CH	4.15
5a	151.6, qC		151.9, qC		157.7, qC	
6	96.4, qC		96.2, qC		93.9, CH	5.26
7	148.6, qC		*c*		180.8, qC	
8	167.8, qC		*c*		172.6, qC	
8a	124.6, qC		124.0, qC		125.5, qC	
8b	123.0, qC		123.5, qC		126.2, qC	
9	174.3, qC		176.9, qC		178.0, qC	
10	49.8, CH_2	3.85 (ddd, 14.6, 12.4, 2.9, H_{ax}) 3.68 (ddd, 14.6, 4.2, 2.0, H_{eq})	50.0, CH_2	3.43 (m, H_{ax}) 3.41 (m, H_{eq})	49.9, CH_2	3.65 (H_b) 3.22 (H_a)
11	29.0, CH_2	2.42 (dddd, 12.9, 5.1, 2.9, 2.0, H_{eq}) 1.88 (dddd, 12.9, 12.4, 11.8, 4.2, H_{ax})	28.8, CH_2	2.11 (dm, 11.9, H_{eq}) 1.58 (dddd, ~12, ~12, 11.8, 4.8, H_{ax})	26.7, CH_2	1.96
12	46.7, CH	3.78 (dd, 11.8, 5.1, H_{ax})	46.8, CH	3.57 (dd, 11.8, 4.7, H_{ax})	38.5, CH_2	3.01
14	58.8, CH_2	4.59 (d, 14.1, H_{eq}) 4.47 (d, 14.1, H_{ax})	65.6, CH	4.40 (q, 6.6, H_{ax})		
16			20.3, CH_3	1.20 (d, 6.6)		

[a] ^{1}H: 600 MHz, CD_3OD, 280 K, ^{13}C: 151 MHz, CD_3OD, 280 K. [b] ^{1}H: 900 MHz, D_2O, 280 K (300 K for **5**), ^{13}C: 226 MHz, D_2O, 280 K (300 K for **5**). [c] Missing signals due to low sample amount.

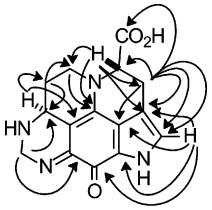

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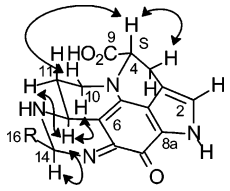
Figure 1. Sanguinone A (**1**) with selected HMBC correlations.



R = H: **1**
R = CH_3: **2**

Figure 2. Sanguinones A (**1**) and B (**2**) with selected NOE correlations.

The relative configuration of **1** was established from the coupling constants in the proton NMR and from NOE measurements. The proton at C-4 is located in the pseudoaxial position since it showed one large (J = 7.6 Hz) and one small coupling constant (J = 1.0 Hz) to the diastereotopic protons at C-3. Proton H-4 showed only a NOE to the pseudoequatorial proton at δ_H 3.68 located at C-10. Therefore, H-10_{eq} is located on the same side of the molecule as the hydrogen at C-4. The pseudoequatorial position was assigned to the proton resonance at δ_H 3.68, since it exhibited only one large coupling constant (J = 14.6 Hz) as a result of coupling with the geminal proton H-10_{ax} at δ_H 3.85. A NOE from H-10_{ax} to H-12 at δ_H 3.78 revealed that this proton had to be axial, pointing in the same direction as H-10_{ax} (Figure 2). This assignment of the relative configuration at C-4 and C-12 was confirmed by the coupling constants of the CH_2CH_2CH moiety in the ^{1}H NMR spectrum (Table 1).

The CD spectra of **1** and **5** were almost identical, which established the *S* configuration at C-4. In combination with the assignment of the relative configuration deduced above, the absolute configuration of sanguinone A (**1**) is therefore 4*S*,12*S*. The 4*S* configuration of **1** is also in agreement with its hypothetical biosynthesis from L-tryptophan, *S*-adenosylmethionine, and glycine.

In contrast to **5**, sanguinone A (**1**) is stable only for a few hours in H_2O or MeOH at room temperature; hence its NMR spectra were recorded at 280 K. Decarboxydehydrosanguinone A (**4**) was identified as a decomposition product of **1** from its ESIMS, ^{1}H NMR, COSY, and NOESY spectra. Obviously, **4** is generated from **1** via an oxidative decarboxylation. In contrast to the blue sanguinone A (**1**), **4** is a yellow solid. Despite the instability of **1** in H_2O, decomposition product **4** seems to be absent in intact fruiting bodies.

The minor blue alkaloid sanguinone B (**2**) exhibited a UV/vis spectrum similar to that of **1**. The ESIMS revealed an $[M + H]^+$ ion at m/z = 313, 14 mass units higher than the molecular ion of **1**. This mass difference indicated replacement of a hydrogen by a CH_3 group. In addition, the ESIMSMS of **2** showed fragments (m/z = 270, 224, 197) identical to those of **1**. Obviously, in the first step, a $CH_3-CH{=}NH$ fragment is expelled instead of a $CH_2{=}NH$ moiety, pointing to structure **2** for sanguinone B. This result was confirmed by the NMR data recorded at 280 K in D_2O. An additional doublet originating from a CH_3 group occurred at δ_H 1.20 in the ^{1}H NMR spectrum. The protons of the CH_3 group exhibited couplings to a quartet of a CH group at δ_H 4.40. This CH group replaced the two doublets at δ_H 4.59 and 4.47 of the diastereotopic CH_2 group of **1**. The other signals of the proton NMR strongly resembled those in the ^{1}H NMR of **1**. Hence, an additional CH_3 moiety replaces one hydrogen at C-14 in **2** and establishes a new stereocenter at C-14.

The CD spectrum of **2** closely resembled that of **1**. Therefore, the configuration at C-4 in **2** is also *S*. The configuration at C-12 was deduced analogously via coupling constants and NOEs as was demonstrated for **1** and is also *S*. A NOE from H-12_{ax} to the proton at δ_H 4.40 placed this proton in the axial and the 16-CH_3 group in the equatorial position, leading to the *S* configuration for C-14 (Figure 2).

The red alkaloid sanguinolentaquinone (**3**) exhibited absorption maxima at λ 241, 341, and 531 nm and an $[M + H]^+$ ion at 265.1181, which corresponded to the molecular formula $C_{13}H_{16}N_2O_4$. The proton NMR revealed signals at δ_H 6.98 and 5.33, which resembled the aromatic proton signals of **5**. Moreover, these protons of **3** exhibited correlations to carbon signals with shift values similar to the corresponding ones in mycenarubin A. Therefore, sanguinolentaquinone contains a 7,8-indoloquinone moiety. The ^{1}H NMR and the COSY spectra revealed two different spin systems. The first consisted of two triplets at δ_H 3.72 and 2.74, assigned to a

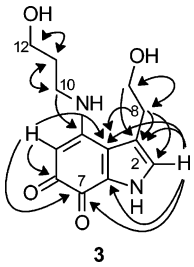


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Figure 3. Sanguinolentaquinone (**3**) with selected HMBC (→) and COSY (↔) correlations.

CH_2CH_2 moiety. This fragment was attached to the quaternary carbon C-3 of the 7,8-indoloquinone moiety, as shown by corresponding couplings in the HMBC from δ_H 2.74 to C-2, C-3, and C-3a. The second spin system consisted of a triplet of triplets at δ_H 1.84 (δ_C 30.2), which showed both $^3J_{HH}$ couplings to a triplet at δ_H 3.45 (δ_C 41.6) and a triplet at 3.62 (δ_C 59.6). Each signal represents two hydrogens that are part of a $CH_2CH_2CH_2$ fragment. This fragment is attached to the indoloquinone carbon C-4 via a nitrogen, as revealed by a $^3J_{CH}$ coupling from the protons at δ_H 3.45 to the resonance at δ_C 160.3. Taking into account the molecular formula in combination with the chemical shift values of C-9 and C-12, OH groups were placed at the ends of the CH_2CH_2 and the $CH_2CH_2CH_2$ groups, leading to structure **3** for sanguinolentaquinone (Figure 3).

Apart from the new alkaloids **1**−**4**, only one other secondary metabolite, hydroxystrobilurin D, has been reported from *M. sanguinolenta*.[3] However, this antifungal-active β-methoxyacrylate antibiotic is not structurally related to **1**−**4** and has been isolated from mycelial cultures rather than from the fruiting bodies.[3b]

In general, pyrroloquinoline alkaloids are relatively rare in terrestrial sources.[4] However, a large number of pyrroloquinoline alkaloids,[4] such as the batzellines,[5] damirones,[6] isobatzellines,[7] makaluvamines,[8] discorhabdins,[9] and wakayin,[10] are known from marine organisms such as marine sponges. Moreover, makaluvamin A has been isolated not only from a marine sponge but also from a culture of the myxomycete *Didymium bahiense*, a terrestial organism.[11] The presence of the sanguinones, the mycenarubins,[2] and haematopodin[12] in *Mycena* species confirms that the occurrence of pyrroloquinoline alkaloids is not restricted to marine sources but also appears to be common in some fungi.

The sanguinones are closely related structurally to discorhabdins D,[13] H,[4,14] L,[14] M,[14] N,[14] and V,[15] prianosin C (2-hydroxydiscorhabdin D),[16] and epinardin A,[17] since these compounds all contain a similar core structure.[4] However, they differ considerably from a biosynthetic point of view since the discorhabdins are obviously produced from tryptophan and phenylalanine/tyrosine,[18] while the sanguinones A (**1**) and B (**2**) are probably derived from tryptophan, *S*-adenosylmethionine, and glycine or alanine, respectively. In contrast to the pyrroloquinoline alkaloids known hitherto from marine sources, the sanguinones and the mycenarubins possess a carboxylic group at C-4. The presence of the carboxylic group supports the hypothesis that pyrroloquinoline and pyrroloiminoquinone alkaloids are in general biosynthetically derived from L-tryptophan.

Discorhabdin D[13] and several other discorhabdins exhibit strong cytotoxicity toward a large panel of tumor cell lines and have therefore attracted considerable interest.[4] However, we were unable to examine the bioactivity of **1** and **2** on account of their instability and the limited quantities of mushroom material available. An ecological role of the pyrroloquinoline alkaloids **1** and **2** and of **3**, beyond their contribution to the color of the fruiting bodies, seems likely, since predators rarely feed on fruiting bodies of *M. sanguinolenta*.

Experimental Section

General Experimental Procedures. Evaporation of the solvents was performed under reduced pressure using a rotary evaporator. Preparative HPLC: Waters 590EF pumps equipped with an automated gradient controller 680 and Kratos Spectroflow 783 UV−vis detector; column: Luna C-18 (2), 5 μm, 15 × 250 mm (Phenomenex); gradient: 10 min at 100% H_2O then within 40 min linear to 100% MeOH; flow rate: 12 mL min^{-1}; detection: UV at 360 nm; UV: Cary 100 Bio (Varian); optical rotation values: P-1030 polarimeter (Jasco); CD: J-715 spectropolarimeter (Jasco); NMR: Bruker DMX 500 spectrometer (^1H at 500.11, ^{13}C at 125.8 MHz), Bruker DMX 600 spectrometer equipped with a cryoprobe (^1H at 600.13, ^{13}C at 150.9 MHz) and Bruker DMX 900 spectrometer equipped with a cryoprobe (^1H at 900.13, ^{13}C at 226.3 MHz), chemical shifts in δ relative to D_2O (δ_H 4.65) or CD_3OD (δ_H 3.31, δ_C 49.00) as internal standard. LCESI mass spectra were recorded with a Gynkotek HPLC equipped with a Luna C-18 (2) column (Phenomenex, 150 × 2 mm, 3 μm, operation temperature 40 °C, flow rate 200 μL min^{-1}, gradient 5 min isocratic at 100% H_2O, then linear to 100% AcCN within 10 min) coupled with a Finnigan TSQ 7000, equipped with a Finnigan ESI ion source interface operating in the positive ESI mode (ionization 4.5 kV, capillary temperature 200 °C, mass range 50−800 mu, multiplier 1000 V (scan modus); MS/MS: argon collision gas 2.0 mbar, sheath gas (N_2) 2.9 bar, multiplier 1400 V, collision energy automatically rotated at −20, −30, −40 eV). LCESIFTICR mass spectra were obtained with an APEX III 70e Fourier transform mass spectrometer (Bruker Daltonics, Billerica, MA). The spectrometer was equipped with an Agilent 1100 HPLC system using a YMC-ODS-AQ C18 column (3 μm, 150 × 2 mm, flow rate 200 μL min^{-1}) (YMC, Dinslaken, Germany). The mobile phase consisted of water containing 0.1% HCO_2H (A) and acetonitrile containing 0.1% HCO_2H (B). Samples were separated using a gradient program as follows: 100% A isocratic for 5 min, linear gradient to 100% B over 15 min. After 100% B isocratic for 5 min, the system returned to its initial conditions (100% A) within 1 min and was held for 10 min before the next run was started.

Mushrooms. Fruiting bodies of *M. sanguinolenta* (leg. et det. S. Peters and P. Spiteller) were collected in September and October 2004, 2005, and 2006 in beech forests near Starnberg, 20 km south of Munich (Bavaria). Voucher samples of *M. sanguinolenta* are deposited at the Institut für Organische Chemie und Biochemie II der Technischen Universität München, Germany. The mushrooms were frozen and stored at −35 °C after collecting.

Extraction and Isolation. Frozen fruiting bodies (100 g) were crushed and extracted with MeOH (2 × 50 mL) at 25 °C for 10 min. The red extract was then concentrated in vacuum at 40 °C. The resulting residue was dissolved in H_2O (5 mL), prepurified with an RP-18 cartridge, and separated by preparative HPLC (UV detection at λ 360 nm). Compounds **1** (5.2 mg) and **2** (0.6 mg) were obtained as blue solids; **3** (1.7 mg), as a red solid. The yellow degradation product **4** was isolated by preparative HPLC (UV detection at λ 440 nm) from a decomposed NMR sample of **1**.

Sanguinone A (1): blue solid; HPLC, t_R = 18.9 min; $[\alpha]_D^{25} = -45$ (*c* 0.0103, H_2O); UV/vis (H_2O) λ_{max} (log ϵ) 251 (3.90), 376 (3.73), 578 (2.64) nm; CD (H_2O) λ ($\Delta\epsilon$) = 247 (−4.9), 274 (+1.9), 297 (+1.0), 304 (+0.95), 363 (−2.9), 584 (+1.5) nm; NMR data, see Table 1; LCESIMS (detection: UV at λ 360 nm) *m/z* = 299 $[M + H]^+$; ESIMSMS (parent ion *m/z* 299, 40 eV) *m/z* (%) 299 $[M + H]^+$ (0.1), 270 $[M + H - H_2C{=}NH]^+$ (84), 254 (5), 243 (6) $[M + H - H_2C{=}NH - HCN]^+$, 224 $[M + H - H_2C{=}NH - (H_2O + CO)]^+$ (100), 209 (7), 197 (26) $[M + H - H_2C{=}NH - (H_2O + CO) - HCN]^+$, 181 (6), 171 (6), 169 (4); HRESIMS *m/z* 299.1133 $[M + H]^+$ (calcd for $C_{15}H_{15}N_4O_3$, 299.1139); HRESIMSMS (parent ion *m/z* 299, 20 eV) *m/z* 299.1133 $[C_{15}H_{15}N_4O_3]^+$, 270.0872 $[C_{14}H_{12}N_3O_3]^+$, 224.0820 $[C_{13}H_{10}N_3O]^+$.

Sanguinone B (2): blue solid; HPLC, t_R = 20.0 min; UV/vis (H_2O) λ_{max} (log ϵ) 247 (3.86), 374 (3.75), 571 (2.59) nm; CD (H_2O) λ ($\Delta\epsilon$) 249 (−4.7), 274 (+1.8), 298 (+1.1), 305 (+1.0), 371 (−2.8), 582 (+1.3) nm; NMR data, see Table 1; LCESIMS (detection: UV at λ 360 nm) *m/z* 313 $[M + H]^+$; ESIMSMS (parent ion *m/z* 313, 30 eV) *m/z* (%) = 270 (100) $[M + H - CH_3CH{=}NH]^+$, 224 (15) $[M + H - CH_3CH{=}NH - (H_2O + CO)]^+$, 197 (4) $[M + H - CH_3CH{=}NH - (H_2O + CO) - HCN]^+$.

Sanguinolentaquinone (3): red solid; HPLC, t_R = 25.0 min; UV/vis (H_2O) λ_{max} (log ϵ) 241 (3.95), 341 (3.81), 531 (2.79) nm; ^1H (500 MHz, D_2O, 298 K) δ 6.98 (1H, s, H-2), 5.33 (1H, s, H-5), 3.72 (2H, t, J = 5.6 Hz, H-9), 3.62 (2H, t, J = 6.1 Hz, H-12), 3.45 (2H, t, J = 6.5 Hz, H-10), 2.74 (2H, t, J = 5.6 Hz, H-8), 1.84 (2H, tt, J = 6.5, 6.1, H-11); ^{13}C (126 MHz, D_2O, 298 K) δ 176.5 (C, C-6), 173.6 (C, C-7), 160.3 (C, C-4), 129.0 (CH, C-2), 128.6 (C, C-7a), 122.1 (C, C-3a), 121.6 (C, C-3), 93.2 (CH, C-5), 62.3 (CH_2, C-9), 59.6 (CH_2, C-12), 41.6 (CH_2, C-10), 30.2 (CH_2, C-11), 28.5 (CH_2, C-8); APCIMS m/z = 265 $[M + H]^+$; APCIMSMS (parent ion m/z 265, 30 eV) m/z 265 (59) $[M + H]^+$, 247 (59) $[M + H - H_2O]^+$, 237 (24) $[M + H - CO]^+$, 219 (53) $[M + H - (H_2O + CO)]^+$, 214 (41), 201 (43) $[M + H - (H_2O + CO) - H_2O]^+$, 189 (100) $[M + H - (H_2O + CO) - CH_2O]^+$, 161 (35) $[M + H - (H_2O + CO) - CH_2O - CO]^+$; HRESIMS m/z 265.1181 ($[M + H]^+$ calcd for $C_{13}H_{17}N_2O_4$, 265.1183).

Decarboxydehydrosanguinone A (4): yellow solid; HPLC, t_R = 17.4 min (H_2O containing 0.1% AcOH was used instead of pure H_2O; detection: UV at λ 440 nm, other conditions as mentioned under General Experimental Procedures); UV/vis (H_2O) λ_{max} (log ϵ) 231 (3.32), 252 (3.19), 428 (3.05), 452 (3.25) nm; ^1H (600 MHz, CD_3OD, 280 K) δ 7.95 (1H, s, H-2), 7.73 (1H, d, J = 6.8 Hz, H-4), 7.48 (1H, d, J = 6.8 Hz, H-3), 4.67 (1H, d, J = 13.1 Hz, H-14_{eq}), 4.64 (1H, ddd, J = 13.7, 4.4, 2.4 Hz, H-10_{eq}), 4.57 (1H, ddd, 13.7, 13.0, 2.9 Hz, H-10_{ax}), 4.50 (1H, d, J = 13.1 Hz, H-14_{ax}), 4.02 (1H, dd, J = 11.7, 5.3 Hz, H-12), 2.65 (1H, dddd, J = 13.3, 5.3, 2.9, 2.4 Hz, H-11_{eq}), 2.00 (1H, dddd, J = 13.3, 13.0, 11.7, 4.4 Hz, H-11_{ax}); ESIMS m/z = 253 $[M + H]^+$; ESIMSMS (parent ion m/z 253, 20 eV) m/z (%) = 253 (30) $[M + H]^+$, 224 (100) $[M + H - H_2C{=}NH]^+$.

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Supporting Information Available: Selected UV/vis, CD, NMR, and mass spectra of compounds **1**−**4**. This material is available free of charge via the Internet at http://pubs.acs.org.

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