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On benzo[*b*][1,4]diazepinium-olates, -thiolates and -carboxylates as anti-Hückel mesomeric betaines

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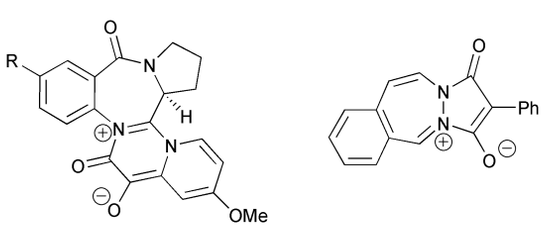
2,3-Diaminophenol **4**, 3,4-diaminophenol **5**, 4-methoxy-1,2-diaminobenzene **6**, 3,4-diaminobenzenethiol **7**, 2,3-diaminobenzoic acid **8**, and 3,4-diaminobenzoic acid **9** were reacted with 2,4-pentanedione to yield the corresponding benzo[*b*][1,4]diazepinium salts, respectively. The hydroxy-benzo[*b*][1,4]diazepinium salts **17** and **18** do not form mesomeric betaines (MB) on deprotonation. Instead, they are converted into the diimines **24** and **25**. By contrast, the 7-mercaptobenzo[*b*][1,4]diazepinium salt **20** yields the corresponding thiolate on increasing the pH of the solution. This MB, which possesses 4*n* π-electrons, does not fit into the classification system of heterocyclic mesomeric betaines accepted today. Deprotonation of the betaine results in the formation of an instable anionic thiolate **31** which oxidizes immediately to the disulfide **32**. The carboxy derivatives **21** and **22** readily form cross-conjugated mesomeric betaines. Whereas the diimine **34** proved to be instable, the sodium salt of the diimine **36** was unambiguously characterized. An X-ray single crystal analysis of **22** as its picrate is presented in order to gain additional insights into these 4*n* π-electron systems.

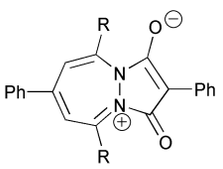
Introduction

Since the first preparation of a mesomeric betaine (MB) by Emil Fischer[1] and the recognition that certain representatives play important biological roles as modified nucleobases[2] or alkaloids,[3] this class of compounds has found considerable interest as valuable starting materials for the synthesis of heterocycles[4] and natural product analogs,[5] drugs,[6] or indicators.[7] It is apparent that only little information is available on seven-membered heterocyclic mesomeric betaines. Recently, the alkaloids Circumdatin A **1a** and B **1b** were isolated from *Aspergillus ochraceus*[8] (Scheme 1). Although the seven-membered ring is not involved in charge-separation, they are representatives of heterocyclic mesomeric betaines that occur as alkaloids or nucleobases in nature.[3] The structures **2** and **3** are mentioned in the literature.[9] The betaine **2**, which was only identified by mass spectrometry, rapidly decomposed in solution. The syntheses of **3a** and **3b** failed. The reason for these instabilities is the number of 4*n* π-electrons (*n* = 3 or 2) in the cationic part which contradicts the Hückel rule of aromaticity.



1a: R = OMe
1b: R = H

2



3a: R = Ph
3b: R = 4-C_6H_4OMe

Scheme 1

In continuation of our work on heterocyclic mesomeric betaines[10] and highly charged heteroarenium compounds[11] we became interested in synthesizing and studying new types of anti-Hückel mesomeric betaines. We took an intramolecular proton shift into consideration which would form an anionic and a cationic partial structure. For the case of the benzo[*b*]-[1,4]diazepinium (1,5-benzodiazepinium) ring system, we intended to take advantage of the destabilizing number of electrons to force a charge-separation to a mesomeric betaine as shown in Scheme 2. It is known that the diimine form **II** of this ring system, from which numerous examples have been described, is more stable than the conjugated form **I**.[12] The latter would have 4*n* π-electrons associated with the seven-membered ring, which is electronically an analog of benzocyclooctatetraene. There is no positive contribution to the stability of the system by annular conjugation around either the diazepine ring or the overall periphery. Obviously, electronic interaction between the benzene ring and the two imino groups in the diimino form **II** and formation of the 3*H* tautomer, however, causes a considerable stabilization.[13] To the best of our knowledge, the conversion into the mesomeric betaine **III**, which would have 4*n* π-electrons, has never been observed to date. Betaine **III** contained a stabilizing, intensely colored vinamidinium chromophore **VI** which is known to overcome the destabilizing influence of the number of 4*n* π-electrons in 1,5-benzodiazepinium salts such as **IV**.[14] In strongly acidic media, almost colorless bisiminium salts such as **V** have been observed.[12] In 1985 it was recognized that natural as well as synthetically prepared mesomeric betaines including the class of mesoions such as sydnones, münchnones and derivatives can be divided into four major classes, *i.e.* conjugated (CMB), cross-conjugated (CCMB), and pseudo-cross-conjugated mesomeric betaines (PCCMB) and conjugated heterocyclic *N*-ylides which are related to CMB.[15] We felt that the type of conjugation in the target 4*n* π-electron mesomeric betaines **III** would not fit into this classification system (*vide infra*).

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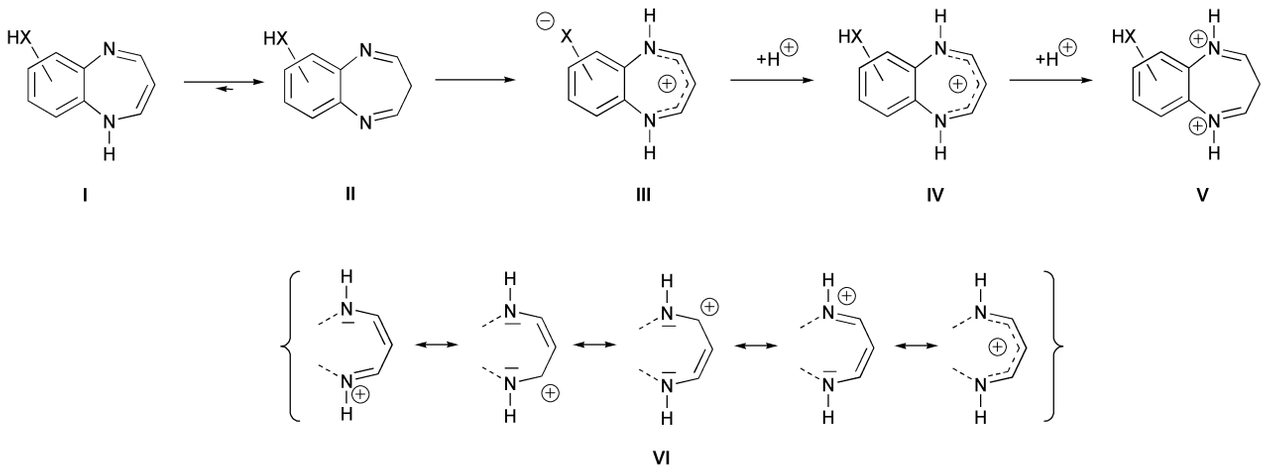


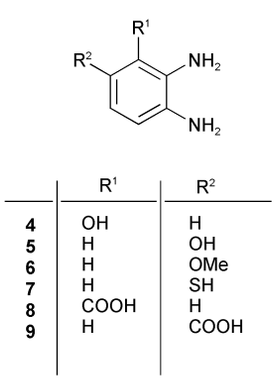
Scheme 2

In addition to this, benzo[*b*][1,4]diazepines form a class of ongoing interest both from a chemical and a biological point of view. Thus, depending on the substitution pattern this ring system displays physiological effects as tranquilizers[16] or antidepressant agents.[17] Some derivatives act as depressants of the central nervous system and anticonvulsants, whereas others act as stimulants of the central nervous system and convulsants.[18] Antibacterial activities,[19] inhibitory effects on the growth of certain sarcomas in rats[20] as well as post emergence herbicidal activities have been reported as well.[21]

Results and discussion

Syntheses

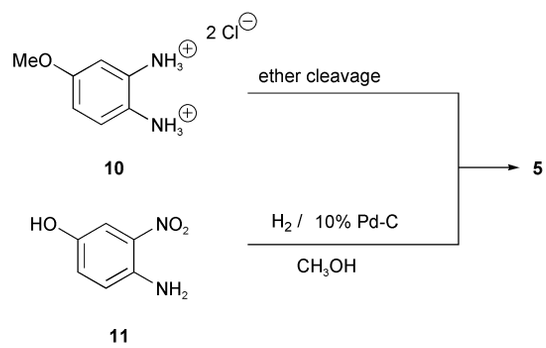
We chose 2,3-diaminophenol **4**, 3,4-diaminophenol **5**, 3,4-diaminobenzenethiol **7**, 2,3-diaminobenzoic acid **8** and 3,4-diaminobenzoic acid **9** (Scheme 3) as starting materials for the synthesis of betainic benzo[*b*][1,4]diazepines and as potentially negatively charged building elements of the target mesomeric betaines which would result from the formation of olate, thiolate, and carboxylate groups, respectively. For spectroscopic comparison we used 4-methoxy-1,2-diaminebenzene **6** which cannot be deprotonated.



	R^1	R^2
4	OH	H
5	H	OH
6	H	OMe
7	H	SH
8	COOH	H
9	H	COOH

Scheme 3

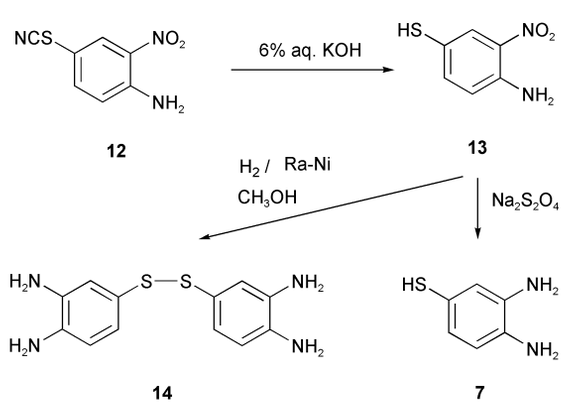
The aromatics **5** and **7** were unknown, and the benzoic acid **8** was prepared by a modification of a patented procedure as described below. As ether cleavage of 4-methoxy-1,2-diaminobenzene dihydrochloride **10**, readily available by catalytic hydrogenation of 4-methoxy-2-nitroaniline in the presence of palladium/charcoal,[22] with HI, 48% HBr/tetra-*n*-butylphosphonium bromide and thiophenolate, respectively, proved to give only unsatisfactory yields of the starting material **5**, we chose an alternative approach. Thus, we found that hydrogenation of 4-amino-3-nitrophenol **11** in the presence of



Scheme 4

catalytic amounts of 10% Pd–C resulted in the formation of 3,4-diaminophenol **5** in good yield (Scheme 4).

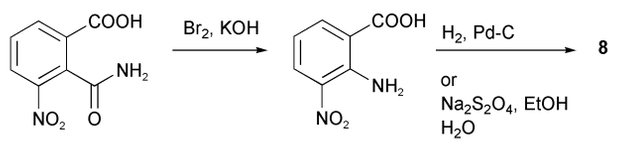
3,4-Diaminobenzenethiol **7** was synthesized in a three-step procedure. Sequential treatment of 2-nitroaniline with sodium thiocyanate and bromine in glacial acetic acid afforded 2-nitro-4-thiocyanatoaniline **12** in good yield.[23] We treated **12** with potassium hydroxide in ethanol to obtain 4-amino-3-nitrobenzenethiol **13** in 68% yield. The existence of the mercapto function was proved by a singlet at δ 3.42 ppm in ^{1}H NMR spectroscopy which corresponds to one proton. Catalytical hydrogenation of **13** in the presence of Raney-nickel immediately yielded the symmetric disulfide **14** *via* the monomeric form on exposure to air in 54% yield (Scheme 5). This dimerization with atmospheric air in alkaline media has also been observed with other aromatic thiols[24] and can be monitored by the spontaneous formation of a nonpolar spot on the TLC. Correspondingly, the molecular peak is found at *m*/*z* = 279.1 amu ($M + H^+$) in ESI mass spectrometry. We found that performing the reduction of **13** with sodium dithionite in aqueous ethanol resulted in the formation of the desired starting material **7** in



Scheme 5

excellent yield. The thiol group gives a resonance frequency at δ 3.36 ppm in ^{1}H NMR spectroscopy.

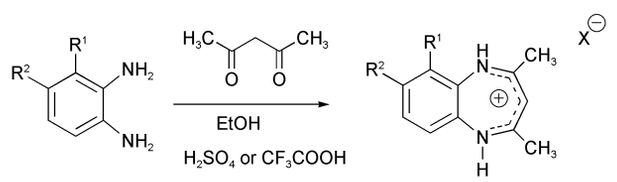
2,3-Diaminobenzoic acid **8** was prepared starting from 2-nitrophthalic acid anhydride[25] which was treated with ammonia to yield 3-nitrophthalamic acid **15**. Hofmann rearrangement with potassium hydroxide and bromine afforded 2-amino-3-nitrobenzoic acid **16** which was finally reduced with hydrogen in the presence of palladium/charcoal or sodium dithionite in 50% aqueous ethanol to 2,3-diaminobenzoic acid **8** which we obtained as brown needles after recrystallization (Scheme 6).



15 **16**

Scheme 6

The diamines were reacted with stoichiometric amounts of 2,4-pentanedione in ethanol at room temperature in the presence of sulfuric acid or trifluoroacetic acid to give the corresponding 1,5-benzodiazepinium salts **17a**,**b**–**22a**,**b** in high yields as intensely violet solids, respectively (Scheme 7).[26] It proved to be advantageous to conduct the condensation of the less reactive α-carboxy derivative **8** to **21a** in hydrochloric acid. Anion exchange to hydrogensulfate was then accomplished with excess sulfuric acid.



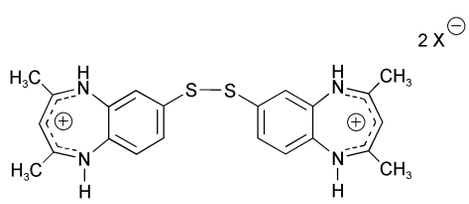
4 - 9

17a - 22a: X = HSO_4
17b - 22b: X = CF_3COO

	R^1	R^2
4, 17	OH	H
5, 18	H	OH
6, 19	H	OMe
7, 20	H	SH
8, 21	COOH	H
9, 22	H	COOH

Scheme 7

The bisulfide **14** yielded the bis(benzodiazepinium) salts **23** (Scheme 8).



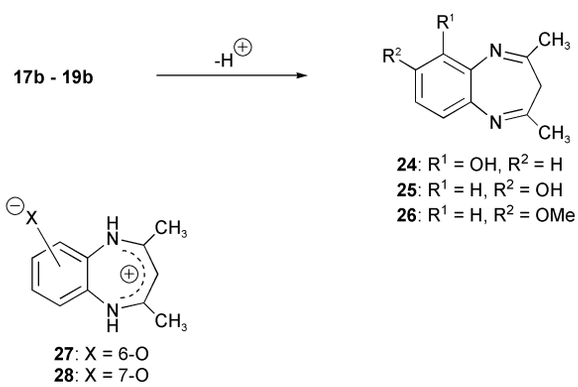
23a: X = HSO_4
23b: X = CF_3COO

Scheme 8

Depending on the substitution pattern the benzo[*b*][1,4]-diazepinium hydrogensulfates **17a**–**23a** and the trifluoroacetates **17b**–**23b** display characteristic UV-VIS absorption maxima between λ_{max} (H_2O) = 482 and 536 nm which is due to the stabilizing vinamidinium chromophor. Correspondingly, C(3) of the salts **17**–**23** give signals between δ 94 and 99 ppm in ^{13}C NMR spectroscopy, and the NH groups of the chromophore are detectable at δ 9.82–10.75 and 9.68–9.82 ppm in DMSO-d_6, respectively. All attempts to methylate the salts at the vinamidinium chromophore with methyl iodide in DMF in the presence of potassium carbonate, or dimethylsulfate, methyltrifluoromethylsulfonate, and Meerwein's reagent failed.

Betaine formation

The trifluoroacetates were used for titrations in order to eliminate protonation/deprotonation equilibria between hydrogensulfate and sulfate. The pK_a values for the monocation **IV**/base **II** equilibria of benzo[*b*][1,4]benzodiazepines, which is a combination of the equilibria of the species **I**, **II** and **IV** depicted in Scheme 2, were determined to be approximately 5.[27] The pK_a for the monocation **IV**/dication **V** equilibria was found to be approximately −1.[24,28] Titration of 6-hydroxybenzo[*b*]-[1,4]diazepine **17b** with 0.1 M NaOH gives a typical titration curve of a weak acid with a strong base. The release of a proton from one of the NH groups (pK_a 7.8 in H_2O at 25 °C) results in the immediate formation of the diimine form **24** (Scheme 9). An analogous behaviour was observed on titration of the 7-hydroxy and the 7-methoxy derivatives, the pK_a values of which were determined to be 8.9 and 6.8 in water at 25 °C, respectively. These deprotonations can easily be observed by a decolorization of the initially deeply violet solutions to pale yellow and can be monitored by UV-VIS spectroscopy. On deprotonation, the aromatic protons 7-H, 8-H and 9-H of *e.g.* **17b** shift from δ 6.54, 6.79 and 5.99 ppm, respectively, to δ 7.02, 6.72 and 6.65 ppm. In the diimine form, the OH protons of **17b** and **18b** are still detectable at δ 8.69 and δ 9.12 ppm, respectively. A comparison with the methoxy derivatives **19b** and **26** reveal that mesomeric betaines such as **27** and **28** do not form.



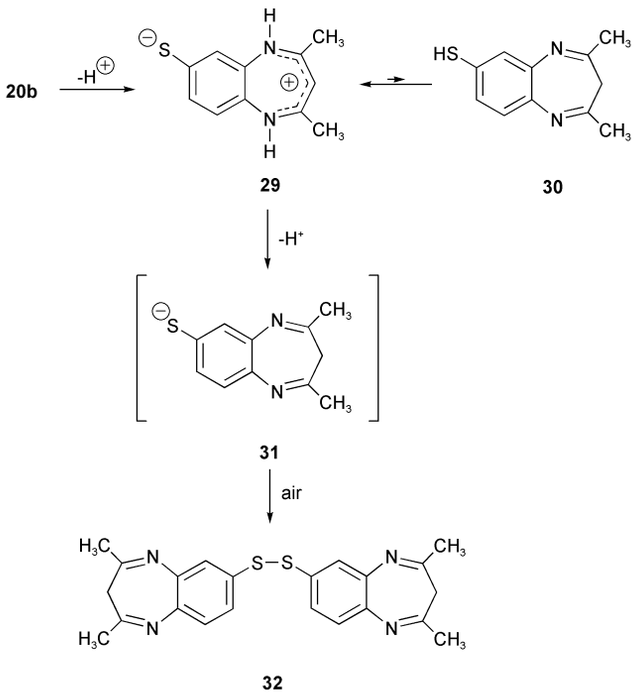
24: R^1 = OH, R^2 = H
25: R^1 = H, R^2 = OH
26: R^1 = H, R^2 = OMe

27: X = 6-O
28: X = 7-O

Scheme 9

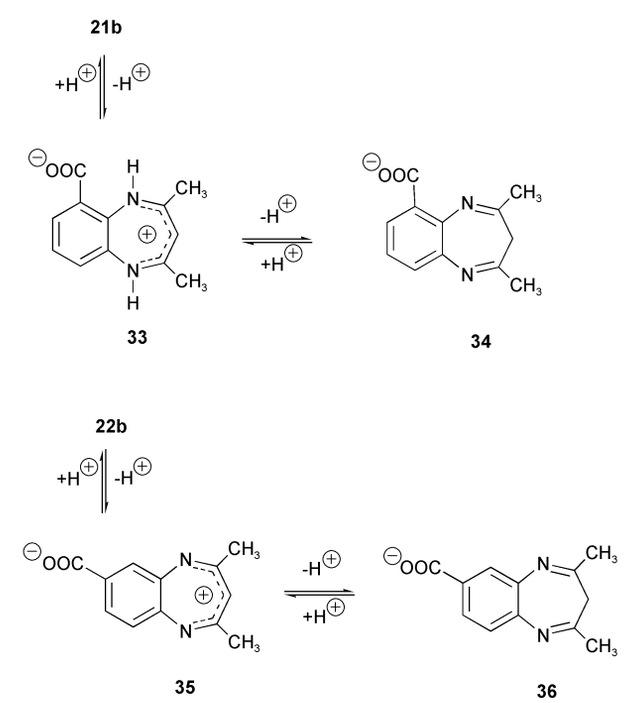
By contrast, the thiol **20b** readily forms a mesomeric betaine **29** as violet solid on increasing the pH of the solution. Two pK_a values at 3.3 and 7.1 were determined on titration of **20b** with 0.1 M NaOH in water at 25 °C. Unambiguously, the mesomeric betaine and not the tautomeric diimine **30** forms at pK_a = 3.3, because the characteristic UV-VIS absorption maximum at λ_{max} = 536 nm remains unchanged. Thus, the vinamidinium chromophore still is intact. The second release of a proton obviously forms the instable anionic species **31** which immediately dimerizes on air to the pale yellow colored disulfide **32** (Scheme 10). Correspondingly, no anionic species was detected in the electrospray ionisation mass spectra (ESIMS) measured in the negative ion detection mode. Instead, in accordance to structure **32** the base peak of the spectrum is detected at *m*/*z* = 429.0 amu (M + Na^+) in the positive ion detection mode spraying from methanol.

Next, we turned our attention to the benzoic acid derivatives **21** and **22**. In agreement with the spontaneous formation of mesomeric betaines in water, aqueous solutions of the salts are



Scheme 10

acidic while UV absorption maxima of the vinamidinium chromophore are found at λ_{max} (H_2O) = 498 nm and 520.0 nm, respectively. On titration of **21b** with 0.1 M NaOH in water at 25 °C the mesomeric betaine **33** (Scheme 11) precipitates as a slightly violet solid at pH values above 2.6, and at pH above 8.8 the mixture becomes colorless. However, we were not able to isolate the anionic species **34** which decomposed according to a NMR taken in D_2O–NaOD. The titration of the carboxy derivative **22b** with 0.1 M NaOH (Fig. 1) clearly proves the release of two protons on increasing the pH. The pK_a values were determined to be 4.8 and 9.8, and can unambiguously be attributed to the deprotonation of the carboxylic acid which causes the formation of the mesomeric betaine **35**, followed by deprotonation of the vinamidinium chromophore, forming the diimine **36** as the sodium salt.



Scheme 11

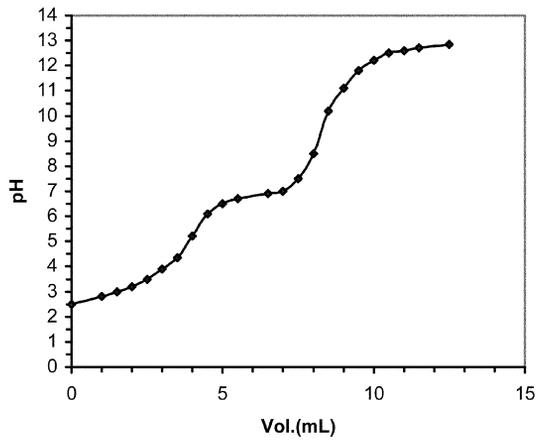


Fig. 1 Titration curve of **22b** (NaOH, 0.1 M).

The cation–betaine transition can unambiguously be proved by UV-VIS spectroscopy. Thus, the vinamidinium group remains intact after the first deprotonation, as an absorption maximum at λ_{max} = 526 nm is detectable in the range between pH 2.2 (pure substance in H_2O) and 7.0 (Fig. 2).

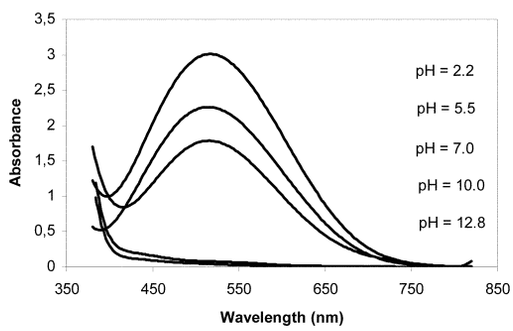


Fig. 2 Absorbance *vs.* wavelength (nm) of **22b** at various pH values in H_2O (0.25% w/v)

The formation of the mesomeric betaine **35** is accompanied by a broadening of the ^{1}H NMR signals which shift slightly to lower (6-H) and higher field (9-H), respectively. ^{1}H NMR measurements of **22b** in D_2O at various pD values adjusted by 0.1 M NaOD in D_2O were performed in order to confirm the structure, and to exclude decompositions, ring contractions to benzimidazoles, or ring cleavages from consideration.[12] We focused our attention on the benzene ring protons, because these protons are more stable toward exchange with deuterium (Fig. 3). In accordance with the results of the NMR titration and the UV/VIS measurements, the ^{1}H NMR taken in D_2O at pD 5.1 display the pure betaine **35**, whereas the spectra between pD 5.70 and 7.20 show a mixture of the mesomeric betaine and the diimine **36**. The anionic diimine **36** gives resonance frequencies at δ 7.79 (6-H), 7.71 (8-H), 7.14 (9-H) and 2.82 ppm (CH_2) in DMSO-d_6, and the imine carbon atoms appear at δ 158.31 and 157.91 ppm in ^{13}C NMR spectroscopy. The electrospray ionization mass spectrometric measurements of the pure compound clearly proves the existence of a sodium salt. Thus, the

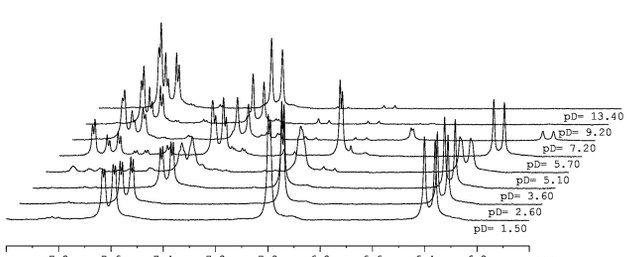


Fig. 3 ^{1}H NMR spectra of **22b** at various pD values at 25 °C.

intense peak of the anion $C_{12}H_{11}N_2O_2^-$ of **36** is detected at *m*/*z* = 215.1 amu (100%) in the negative ion detection mode, spraying a sample from methanol at 0 V fragmentor voltage. An additional peak is found at *m*/*z* = 454.1 amu which corresponds to a dimerised anionic species plus one sodium.

X-Ray analysis of 22

In order to gain additional insights into the structure we tried to obtain single crystals for an X-ray analysis. We were finally successful by slow evaporation of a concentrated solution of a 1 : 1 mixture of 7-carboxy-2,4-dimethyl-5*H*-benzo[*b*][1,4]-diazepinium **22** and picric acid in methanol. As a consequence of the strong acidity of picric acid (pK_a 0.25), the substance crystallized as a salt. The elemental cell contains three molecules, the benzodiazepinium cation, the picrate anion, and one molecule of methanol. The crystallographic numbering of the molecule is shown in Fig. 4.

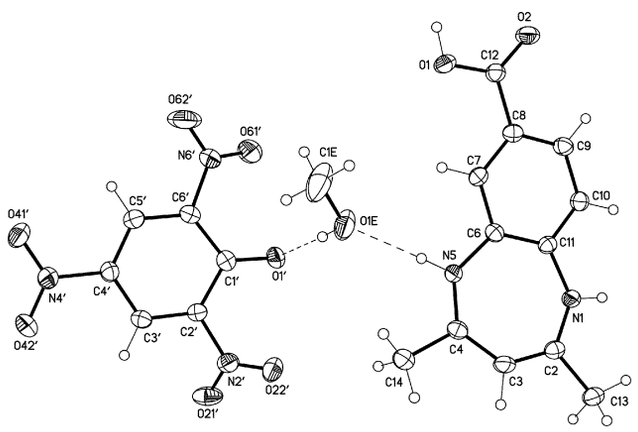


Fig. 4 ORTEP plot of **22** as the picrate.

As a confirmation of the ^{1}H NMR spectrum and titration curve, the ORTEP[29] drawing shows the presence of a COOH group which is slightly twisted out of the plane of the benzene ring and which is hydrogen bonded to the COOH group of another molecule. The corresponding dihedral angle C(7)–C(8)–C(12)–O(2) is 175.74(17)°. In addition, the nitrogen atoms are slightly twisted out of the plane of the benzene ring [N(5)–C(6)–C(11)–C(10) 177.16(16)°], and the seven-membered ring is slightly twisted as well [C(3)–C(4)–N(5)–C(6) −6.4(3)°; C(11)–N(1)–C(2)–C(3) 4.6(3)°]. By contrast, X-ray analyses of 2,4-dimethylbenzodiazepinium chloride[30] and hexafluorophosphate[31] as well as of the hydrochloride of 2,4-dimethylnaphthodiazepine[32] showed nearly planar structures. The vinamidinium chromophore has bond distances characteristic of a fully delocalised 6π push–pull electron system. Thus, the bond lengths N(1)–C(2) and C(4)–N(5) are 1.334(2) and 1.323(2) Å, respectively. The bond distances between C(2) and C(3), and between C(3) and C(4) were determined to be 1.384(3) and 1.394(3) Å, respectively, and are longer than corresponding bond lengths in reported molecules.[24,25] As the bond distances between the vinamidinium chromophore and the benzene ring are very large [N(1)–C(11) 1.419(2) Å; N(5)–C(6) 1.426(2) Å] for C(sp^2)–N-bonds, there obviously is no considerable electronic interaction between these two parts of the molecule. This result strongly confirms, that the 4*n* π-mesomeric betaines described here contains isolated cationic and anionic segments as in **VI** (Scheme 2), and that the charges are exclusively restricted to separate parts of the conjugated system. In the crystal the benzodiazepinium molecules form several hydrogen bonds (Fig. 5). The N(1)H (crystallographic numbering) forms a hydrogen bond to the olate group of the picrate, and N(5)H to the methanol of crystallisation oxygen atom. Two molecules form stacks at a distance of 343 pm which is slightly more than the two-fold van der Waals radii of carbon

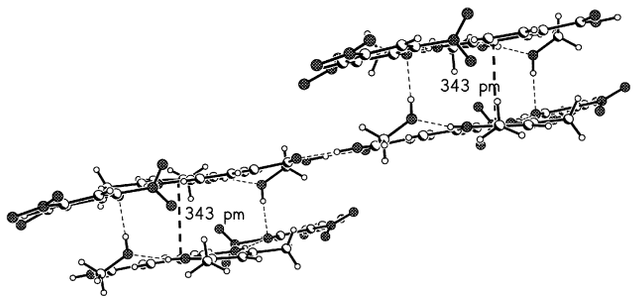


Fig. 5 ORTEP drawing of the hydrogen-bonded tetrameric interactions of compound **22** as the picrate.

atoms (r_{vdW} = 165–170 pm). Two benzodiazepinium molecules are head-to-tail orientated. The stacked molecules are additionally connnected by two sets of three N(5)–H ··· (Me)O–H ··· $OC_6H_2(NO_2)_3$ ··· N(1)′–H hydrogen bonds.

Classification of the 4*n* π-electron mesomeric betaines

Structures of the mercaptobetaine **29** can be drawn with the negative charge delocalized in the benzene ring as well as in the seven-membered ring (Fig. 6). Formally, common atoms for the delocalization of the positive as well as of the negative charges exist, and this fact is characteristic for conjugated mesomeric betaines (CMB). As the X-ray analysis of **22** revealed, however, obviously there is *no conjugation* between the positive and the negative part of the molecule, because this would result in the conjugation of 4*n* π-electrons. Thus, the classification of **29** as a conjugated mesomeric betaine seems not to be unambigous. In contrast, regardless of the long C–N bonds, the negative charges in the mesomeric betaines **33** and **35** are *exclusively* restricted to separated parts of the molecule which is characteristic for cross-conjugated mesomeric betaines (CCMB).[9,15]

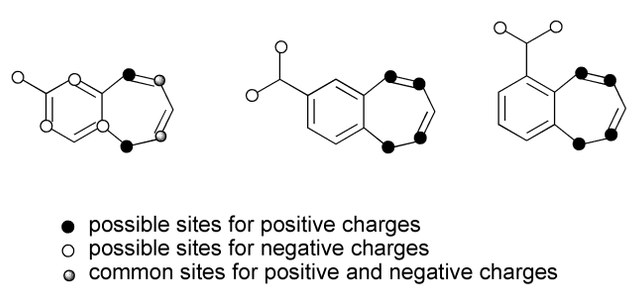


Fig. 6 Charge distribution according to the canonical formulae of benzodiazepinium-olates and -thiolates (left), and -carboxylates (middle and right).

Experimental

General methods

The ^{1}H and ^{13}C NMR spectra were recorded on Bruker ARX-400 and DPX-200 spectrometers and were taken in DMSO-d_6 and $CDCl_3$ at 200 and 400 MHz. The chemical shifts are reported in ppm relative to internal tetramethylsilane (δ 0.00). Multiplicities are described by using the following abbreviations: s = singlet, d = doublet, t = triplet, m = multiplet, br = broad. FT-IR spectra were obtained on a Bruker Vektor 22 in the range 400–4000 cm $^{-1}$ (2.5% pellets in KBr). The GC-MS spectra (EI) were recorded either on a GC Hewlett Packard 5980, Serie II/MS Hewlett Packard 5989 B, or on a Varian GC3900 with SAT2100T. The ESI mass spectra were measured with an Agilent LCMSD Series HP1100 with APIES. Samples were sprayed from methanol at 0V fragmentor voltage unless otherwise noted. All reactions were monitored by analytical thin layer chromatography using silica gel 60 F^{254} precoated plates and spots were detected either by UV-absorption or

iodine. All commercially available chemicals were purchased from Fluka and Lancaster Chemical Co. and used as received without further purification.

Crystal structure determination of 22 (picrate)

Crystal data. $C_{19}H_{19}N_5O_{10}$, [($C_{12}H_{13}N_2O_2$) + ($C_6H_2N_3O_7$) + (CH_4O)], M = 477.39, triclinic, space group $P\bar{1}$ (no. 2), a = 8.8117(2), b = 11.0726(2), c = 11.2477(3) Å, α = 79.339(1), β = 73.059(1), γ = 86.946(1)°, U = 1031.68(4) Å^3, T = 123(2) K, Z = 2, μ(Mo-Kα) = 0.127 mm $^{-1}$, 17842 reflections measured, 3648 unique (R_{int} = 0.0368) which were used in all calculations. The final $wR(F^2)$ was 0.1218 (all data).

CCDC reference number 216056.

See http://www.rsc.org/suppdata/ob/b3/b308412d/ for crystallographic data in CIF or other electronic format.

3,4-Diaminophenol 5

Activated palladium on carbon catalyst (10% Pd, 200 mg) was added cautiously as a slurry in methanol (10 cm^3) to a solution of 4-amino-3-nitrophenol **11** (2.0 g, 13 mmol) in methanol (100 cm^3), and the mixture was stirred under a hydrogen atmosphere for 6 h until the absorption of gas ceased. The catalyst was removed by filtration through Celite, and the filtrate was evaporated to dryness under reduced pressure to afford **5** as a dark brown solid (1.50 g, 93%); mp 155 °C (Found: C, 57.7; H, 6.3; N, 22.5. $C_6H_8N_2O$ requires C, 58.0; H, 6.5; N, 22.6%); λ_{max} (MeOH)/nm 343; ν_{max} (KBr)/cm $^{-1}$ 3398, 3353, 3272, 3024, 2931, 1621, 1606, 1510, 1486 and 1382; δ_H (200 MHz; DMSO-d_6; Me_4Si) 4.21 (4H, br s, 2 × NH_2), 5.81 (1H, dd, J 8.1 and 2.6, 6-H), 6.03 (1H, d, J 2.6, C-2), 6.31 (1H, d, J 8.1, 5-H) and 8.12 (1H, br s, OH); δ_C (50 MHz; DMSO-d_6; Me_4Si) 102.2, 103.2, 115.8 (C-2), 126.8 (C-4), 136.7 (C-3) and 149.7 (C–O); m/z (EI) 124 (M$^+$, 100%), 96 (28), 68 (11) and 52 (12).

3,4-Diaminobenzenethiol 7

4-Amino-3-nitrobenzenethiol **13** (3.40 g, 20 mmol) was dissolved in 50% aqueous ethanol (300 cm^3) and then sodium dithionite (13.93 g, 80 mmol) was added portionwise over a period of 20 min. The stirred solution was first refluxed for 1 h and then extracted with chloroform after cooling to room temperature. The aqueous layer was evaporated *in vacuo* and the resulting solids were extracted with methanol. Evaporation of the solvent gave a crude solid which was subjected to column chromatography on silica gel using MeOH–EtOAc (1 : 5) to give a fine dark yellow powder (2.07 g, 74%); mp 174–150 °C; λ_{max} (MeOH)/nm 236 and 318; ν_{max} (KBr)/cm $^{-1}$ 3411, 3398, 3320, 1619, 1578, 1502 and 1282; δ_H (200 MHz; DMSO-d_6; Me_4Si) 3.36 (1H, s, SH), 4.18 (4H, s, 2 × NH_2), 6.42 (1H, d, J 8.1, 5-H), 6.49 (1H, dd, J 8.1 and 1.9, 6-H) and 6.68 (1H, d, J 1.9, 2-H); δ_C (50 MHz; DMSO-d_6; Me_4Si) 114.0, 117.5, 121.6, 122.6, 135.3 and 136.2; m/z (EI) 140 (M$^+$, 100%), 107 (39), 95 (16), 80 (16) and 52 (13).

2,3-Diaminobenzoic acid 8

Sodium dithionite (1.39 g, 8 mmol) was added portionwise over a period of 10 min to a solution of 4-amino-3-nitrobenzoic acid (0.364 g, 2 mmol) in 50% aqueous ethanol (50 cm^3) at room temperature. The reaction mixture was heated under reflux for 1 h and extracted with ethyl acetate (3 × 30 cm^3) after cooling. The combined extracts were dried over magnesium sulfate and evaporated to dryness. The resulting solid was purified by recrystallization from water to give **8** as pale brown needles (0.225 g, 74%); mp 198–200 °C (Found: C, 55.0; H, 5.4; N, 18.4. $C_7H_8N_2O_2$ requires C, 55.2; H, 5.3; N, 18.4%); λ_{max} (MeOH)/nm 232 and 344; ν_{max} (KBr)/cm $^{-1}$ 3420, 3361, 3331, 1635, 1559, 1467 and 1375; δ_H (200 MHz; DMSO-d_6; Me_4Si) 6.36 (1H, t, J 7.8, 5-H), 6.69 (1H, dd, J 7.8 and 1.5, 4-H), 6.86 (4H, br s, 2 × NH_2) and 7.10 (1H, dd, J 7.8 and 1.5, 6-H); δ_C (50 MHz; DMSO-d_6; Me_4Si) 109.7 (C-1), 115.0, 117.2, 119.4, 135.6 (C-2), 139.7 (C-3) and 170.3 (CO); m/z (EI) 202 (M$^+$ – 1, 100%), 187 (77), 147 (24), 119 (10) and 80 (11).

4-Amino-3-nitrobenzenethiol 13

2-Nitro-4-thiocyanatoaniline **12** (3.51 g, 18 mmol) was added portionwise to a stirred solution of potassium hydroxide (6 g) in ethanol (100 cm^3) at 10 °C and the stirring was continued for further 30 min at room temperature. A solution of sulfuric acid in ethanol (5%) was cautiously added whereupon the color of the mixture changed from dark violet to orange. The mixture was then poured into water (400 cm^3) and extracted with ethyl acetate (2 × 100 cm^3). The combined organic extracts were washed with brine, dried over magnesium sulfate, and evaporated to give **13** as a red solid (2.08 g, 68%); mp 99–100 °C (Found: C, 42.2; H, 3.5; N, 16.4. $C_6H_6N_2O_2S$ requires C, 42.3; H, 3.5; N, 16.5%); λ_{max} (MeOH)/nm 343; ν_{max} (KBr)/cm $^{-1}$ 3463, 3344, 2555, 1634, 1554 and 1502; δ_H (200 MHz; $CDCl_3$; Me_4Si) 3.42 (1H, s, SH), 5.85 (2H, br s, NH_2), 6.78 (1 H, d, J 8.7, 5-H), 7.33 (1H, dd, J 8.7 and 2.1, 6-H) and 8.14 (1H, d, J 2.1, 2-H); δ_C (50 MHz; $CDCl_3$; Me_4Si) 116.3, 119.6, 128.3, 139.0 and 143.4 (one signal not detectable); m/z (EI) 202 (M$^+$ – 1, 100%), 187 (77), 147 (24), 119 (10) and 80 (11).

Bis(3,4-diaminophenyl) disulfide 14

A 50% suspension of activated Raney-nickel catalyst (100 mg) in water was washed several times with water and methanol, respectively. A solution of **13** (0.34 g, 2.0 mmol) in methanol (50 cm^3) was added cautiously to the suspension of the catalyst in methanol (5 cm^3), and the mixture was stirred under hydrogen atmosphere for 5 h at room temperature until the absorption of gas ceased. The catalyst was removed by filtration through Celite, and the filtrate was evaporated *in vacuo* to give crude **14**. The product was purified by column chromatography on silica gel using (CH_2Cl_2–EtOAc, 4 : 1). Recrystallization from water afforded a fine dark yellow almost odorless powder (0.54 g, 54%); mp 155 °C (Found: C, 51.3; H, 5.3; N, 20.1. $C_{12}H_{14}N_4S_2$ requires C, 51.7; H, 5.1; N, 20.1%); λ_{max} (MeOH)/nm 230 and 318; ν_{max} (KBr)/cm $^{-1}$ 3414, 3365, 1619, 1578, 1498, 1420 and 1283; δ_H (200 MHz; DMSO-d_6; Me_4Si) 4.62 (4H, s, NH_2), 4.78 (4H, s, NH_2), 6.65 (4H, m, 5,6-H) and 6.68 (2 H, s, 2-H); δ_C (50 MHz; DMSO-d_6; Me_4Si) 114.0, 117.5, 121.6, 122.6, 135.3 and 136.2; m/z (EI) 278 (84%), 140 (M$^+$, 100), 122 (9), 112 (12) and 95 (25).

General procedure for the preparation of the 2,4-dimethyl-5*H*-benzo[*b*][1,4]diazepin-1-ium hydrogensulfates and trifluoroacetates 17a,b–22a,b

Solutions of the diaminobenzene derivatives **4**–**9** (1.0 mmol) in ethanol (20 cm^3) were treated with pentane-2,4-dione (0.1 cm^3, 1.0 mmol) and a few drops of concentrated sulfuric acid or trifluoroacetic acid. The reactions started immediately whereupon the color changed to dark violet. The mixtures were stirred for 30 min at room temperature. After concentrating the ethanolic solutions to 20% of its original volume, addition of diethyl ether precipitated solids which were filtered off and washed with diethyl ether to give intensely violet solids, respectively.

6-Hydroxy-2,4-dimethyl-5*H*-benzo[*b*][1,4]diazepin-1-ium hydrogensulfate 17a

2,3-Diaminophenol **4** (0.124 g, 1 mmol) was used; yield 0.24 g, 92%; mp 195–197 °C (Found: C, 45.7; H, 4.9; N, 9.6. $C_{11}H_{14}N_2O_5S$ requires C, 46.1; H, 4.9; N, 9.8%); m/z (HRESI) Found: 189.1027. $C_{11}H_{13}N_2O$ requires 189.1028; λ_{max} (H_2O)/nm 362 and 492; λ_{max} (MeOH)/nm 368 and 496; λ_{max} (MeCN)/nm 366 and 520; ν_{max} (KBr)/cm $^{-1}$ 3283, 3050, 1623, 1605, 1519 and 1448; δ_H (200 MHz; DMSO-d_6; Me_4Si) 1.80 (3H, s, CH_3), 1.89 (3H, s,

CH_3), 4.32 (1H, s, 3-H), 5.99 (1H, d, *J* 8.2, 9-H), 6.54 (1H, d, *J* 8.2, 7-H), 6.79 (1H, t, *J* 8.2, 8-H), 9.12 (1H, s, NH), 9.62 (1H, s, NH) and 10.75 (1H, s, OH); δ_C (50 MHz; DMSO-d_6; Me_4Si) 24.1 (CH_3), 24.2 (CH_3), 95.8 (CH), 113.7, 116.3, 120.3, 129.8, 136.2, 149.9, 175.2 and 176.6; *m*/*z* (EI) 188 ($M^+ - 1$, 80%), 173 (28), 148 (49) and 64 (100).

6-Hydroxy-2,4-dimethyl-5*H*-benzo[*b*][1,4]diazepin-1-ium trifluoroacetate 17b

2,3-Diaminophenol **4** (0.41 g, 3.3 mmol) was used; yield 0.82 g, 82%; mp 190–193 °C (Found: C, 51.6; H, 4.3; N, 9.2. $C_{13}H_{13}F_3N_2O_3$ requires C, 51.7; H, 4.3; N, 9.3%); *m*/*z* (HRESI) Found: 189.1029. $C_{11}H_{13}N_2O$ requires 189.1028; λ_{max} (H_2O)/nm 492; λ_{max} (MeOH)/nm 370 and 496; λ_{max} (EtOH)/nm 256, 372 and 484; ν_{max} (KBr)/cm $^{-1}$ 3241, 3073, 3005, 1663, 1633, 1607, 1590, 1460 and 1391; δ_H (200 MHz; DMSO-d_6; Me_4Si) 1.80 (3H, s, CH_3), 1.89 (3H, s, CH_3), 4.31 (1H, s, 3-H), 6.00 (1H, dd, *J* 8.1 and 1.1, 9-H), 6.56 (1H, dd, *J* 8.1 and 1.1, 7-H), 6.79 (1H, t, *J* 8.1, 8-H), 9.10 (1H, br s, NH), 9.74 (1H, br s, NH) and 11.06 (1H, s, OH); δ_C (50 MHz; DMSO-d_6; Me_4Si)[33] 24.0 (CH_3), 24.2 (CH_3), 95.7 (CH), 113.7, 116.3, 120.3, 129.8, 136.2, 150.1, 175.1 and 176.4; *m*/*z* (EI) 188 ($M^+ - 1$, 100%), 173 (44), 148 (46), 107 (15) and 79 (11).

7-Hydroxy-2,4-dimethyl-5*H*-benzo[*b*][1,4]diazepin-1-ium hydrogensulfate 18a

3,4-Diaminophenol **5** (0.248 g, 2.0 mmol) was used; yield 0.37 g, 64%; mp 225–227 °C; *m*/*z* (HRESI) Found: 189.1028. $C_{11}H_{13}N_2O$ requires 189.1025; λ_{max} (H_2O)/nm 482; λ_{max} (MeOH)/nm 342 and 464; λ_{max} (EtOH)/nm 262, 346 and 450; ν_{max} (KBr)/cm $^{-1}$ 3214, 3051, 2981, 1643, 1613, 1524, 1481 and 1383; δ_H (200 MHz; DMSO-d_6; Me_4Si) 1.71 (3H, s, CH_3), 1.75 (3H, s, CH_3), 4.08 (1H, s, 3-H), 5.94 (1H, d, *J* 2.5, 6-H), 6.20 (1H, dd, *J* 8.6 and 2.5, 8-H), 6.33 (1H, d, *J* 8.6, 9-H), 9.13 (1H, s, NH), 9.82 (1H, br s, NH) and 9.99 (1H, s, OH); δ_C (50 MHz; DMSO-d_6; Me_4Si) 23.7 (CH_3), 23.8 (CH_3), 94.3 (CH), 110.7, 113.0, 123.5, 125.2, 135.3, 158.3, 172.7 and 173.7; *m*/*z* (EI) 188 ($M^+ - 1$, 100%), 173 (20), 148 (26), 118 (16), 106 (13) and 51 (35).

7-Hydroxy-2,4-dimethyl-5*H*-benzo[*b*][1,4]diazepin-1-ium trifluoroacetate 18b

3,4-Diaminophenol **5** (0.248 g, 2.0 mmol) was used; yield 0.526 g, 87%; mp 181–183 °C; *m*/*z* (HRESI) Found: 189.1028. $C_{11}H_{13}N_2O$ requires 189.1022; λ_{max} (H_2O)/nm 266, 330 and 480; λ_{max} (MeOH)/nm 266, 344 and 460; λ_{max} (EtOH)/nm 268, 284, 346 and 472; ν_{max} (KBr)/cm $^{-1}$ 3443, 3311, 3086, 2998, 1659, 1604, 1538, 1484, 1438, 1397 and 1208; δ_H (200 MHz; DMSO-d_6; Me_4Si) 1.71 (3H, s, CH_3), 1.74 (3H, s, CH_3), 4.06 (1H, s, 3-H), 5.96 (1H, d, *J* 2.5, 6-H), 6.20 (1H, dd, *J* 8.6 and 2.5, 8-H), 6.34 (1H, d, *J* 8.6, 9-H), 9.27 (1H, s, NH), 10.01 (1H, br s, NH) and 10.17 (1H, s, OH); δ_C (50 MHz; DMSO-d_6; Me_4Si)[33] 23.6 (CH_3), 23.7 (CH_3), 94.2 (CH), 110.8, 113.0, 123.5, 125.1, 135.3, 158.4, 172.6 and 173.6; *m*/*z* (EI) 188 ($M^+ - 1$, 100%), 172 (340), 146 (28), 118 (7), 6 (15) and 51 (10).

7-Methoxy-2,4-dimethyl-5*H*-benzo[*b*][1,4]diazepin-1-ium hydrogensulfate 19a

4-Methoxy-*o*-phenylenediamine dihydrochloride **6** (0.422 g, 2 mmol) was used; yield 0.505 g, 91%; mp 210–212 °C; *m*/*z* (HRESI) Found: 203.1180. $C_{12}H_{15}N_2O$ requires 203.1184; λ_{max} (H_2O)/nm 330 and 500; λ_{max} (MeOH)/nm 344 and 506; λ_{max} (MeCN)/nm 332 and 520; ν_{max} (KBr)/cm $^{-1}$ 3407, 3308, 3070, 3005, 1642, 1608, 1528 and 1482; δ_H (200 MHz; DMSO-d_6; Me_4Si) 1.74 (3H, s, CH_3), 1.78 (3H, s, CH_3), 3.64 (3H, s, OCH_3), 4.05 (1H, s, 3-H), 6.23 (1H, m, 9-H), 6.40 (1H, m, 6-H), 6.55 (1H, m, 8-H), 9.52 (1H, s, NH) and 10.19 (1H, s, NH); δ_C (50 MHz; DMSO-d_6; Me_4Si) 23.8 (CH_3), 23.9 (CH_3), 55.8 (OCH_3), 94.7 (CH), 110.7, 111.1, 125.4, 125.9, 135.9, 159.9, 173.0 and 174.1; *m*/*z* (EI) 202 ($M^+ - 1$, 100%), 187 (77), 147 (24), 119 (10) and 80 (11).

7-Methoxy-2,4-dimethyl-5*H*-benzo[*b*][1,4]diazepin-1-ium trifluoroacetate 19b

4-Methoxy-*o*-phenylenediamine dihydrochloride **6** (1.05 g, 5 mmol) was used; yield 1.16 g, 73%; mp 208–210 °C; *m*/*z* (HRESI) Found: 203.1182. $C_{12}H_{15}N_2O$ requires 203.1184; λ_{max} (H_2O)/nm 520; λ_{max} (MeOH)/nm 334 and 522; λ_{max} (EtOH)/nm 334 and 522; ν_{max} (KBr)/cm $^{-1}$ 3045, 2903, 1637, 1602, 1572, 1473 and 1385; δ_H (200 MHz; DMSO-d_6; Me_4Si) 1.76 (3H, s, CH_3), 1.80 (3H, s, CH_3), 3.63 (3H, s, OCH_3), 4.02 (1H, s, 3-H), 6.37 (2H, m, 6,9-H), 6.68 (1H, m, 8-H), 9.82 (1H, s, NH) and 10.53 (1H, s, NH); δ_C (50 MHz; DMSO-d_6; Me_4Si)[33] 23.4 (CH_3), 23.5 (CH_3), 55.4 (OCH_3), 94.3 (CH), 110.3, 110.7, 125.0, 125.5, 135.5, 159.5, 172.6 and 173.7; *m*/*z* (EI) 202 ($M^+ - 1$, 100%), 187 (77), 147 (16) and 118 (7).

7-Mercapto-2,4-dimethyl-5*H*-benzo[*b*][1,4]diazepin-1-ium hydrogensulfate 20a

3,4-Diaminobenzenethiol **7** (0.14 g, 1 mmol) was used; yield 0.256 g, 85% (oily product); *m*/*z* (HRESI) Found: 205.0735. $C_{11}H_{13}N_2S$ requires 205.0799; λ_{max} (H_2O)/nm 264 and 520; λ_{max} (MeOH)/nm 270 and 526; λ_{max} (EtOH)/nm 268 and 524; ν_{max} (film)/cm $^{-1}$ 2977, 1636, 1590, 1508, 1474, 1374, 1283 and 1175; δ_H (200 MHz; DMSO-d_6; Me_4Si) 1.78 (6H, s, 2 × CH_3), 3.37 (s, SH), 4.23 (1H, s, 3-H), 6.50 (1H, d, *J* 8.3, 9-H), 6.63 (1H, d, *J* 1.8, 6-H), 6.99 (1H, dd, *J* 8.3 and 1.8, 8-H), 9.69 (1H, s, NH) and 9.89 (1H, s, NH); δ_C (50 MHz; DMSO-d_6; Me_4Si) 24.0 (2 × CH_3), 95.9 (CH), 121.4, 124.3, 127.3, 133.2, 135.1, 135.9, 175.9 and 176.0; *m*/*z* (EI) 204 ($M^+ - 1$, 18%), 164 (84), 131 (20), 96 (16) and 64 (100).

7-Mercapto-2,4-dimethyl-5*H*-benzo[*b*][1,4]diazepin-1-ium trifluoroacetate 20b

3,4-Diaminobenzenethiol **7** (0.14 g, 1 mmol) was used; yield 0.30 g, 94%; mp 130–132 °C; *m*/*z* (HRESI) Found: 205.0791. $C_{11}H_{13}N_2S$ requires 205.0799; λ_{max} (H_2O)/nm 270 and 516; λ_{max} (MeOH)/nm 272 and 526; λ_{max} (EtOH)/nm 272 and 528; ν_{max} (KBr)/cm $^{-1}$ 3303, 3138, 3065, 1673, 1645, 1596, 1507, 1478 and 1373; δ_H (200 MHz; DMSO-d_6; Me_4Si) 1.77 (6H, s, 2 × CH_3), 3.40 (s, SH), 4.21 (1H, s, 3-H), 6.50 (1H, d, *J* 8.3, 9-H), 6.63 (1H, d, *J* 2.0, 6-H), 6.98 (1H, dd, *J* 8.3 and 2.0, 8-H), 9.90 (1H, s, NH) and 10.08 (1H, s, NH); δ_C (50 MHz; DMSO-d_6; Me_4Si)[33] 23.9 (CH_3), 24.0 (CH_3), 95.9 (CH), 121.4, 124.2, 127.2, 133.4, 135.3, 135.9, 175.7 and 175.8; *m*/*z* (EI) 204 ($M^+ - 1$, 100%), 163 (25), 122 (16), 95 (11), 69 (54) and 51 (26).

6-Carboxy-2,4-dimethyl-5*H*-benzo[*b*][1,4]diazepin-1-ium hydrogensulfate 21a

2,3-Diaminophenol **8** (0.188 g, 1.24 mmol) and concentrated HCl as a catalyst were used. Addition of H_2SO_4 in excess gave the corresponding hydrogensulfate; yield 0.32 g, 80%; mp 182–185 °C (Found: C, 44.9; H, 4.4; N, 8.7. $C_{12}H_{14}N_2O_6S \cdot 1/2\ H_2O$ requires C, 44.6; H, 4.7; N, 8.7%); *m*/*z* (HRESI) Found: 217.0973. $C_{12}H_{13}N_2O_2$ requires 217.0970; λ_{max} (H_2O)/nm 498; λ_{max} (MeOH)/nm 344 and 498; λ_{max} (EtOH)/nm 224, 274 and 338; ν_{max} (KBr)/cm $^{-1}$ 2956, 2823, 1689, 1639, 1594, 1543, 1481 and 1378; δ_H (200 MHz; DMSO-d_6; Me_4Si) 1.89 (3H, s, CH_3), 1.94 (3H, s, CH_3), 4.68 (1H, s, 3-H), 6.82 (1H, dd, *J* 7.9 and 1.4, 9-H), 7.08 (1H, t, *J* 7.9, 8-H), 7.56 (1H, dd, *J* 7.9 and 1.4, 7-H) and 10.47 (2H, s, 2 × NH); δ_C (50 MHz; DMSO-d_6; Me_4Si) 24.4 (CH_3), 25.1 (CH_3), 98.7 (CH), 121.9, 127.9, 128.0, 130.8, 135.4, 138.3, 167.8, 177.5 and 180.7; *m*/*z* (EI) 216 (M^+, 10%), 172 (100), 130 (87), 103 (24), 89 (13), 77 (21), 63 (34) and 51 (24).

6-Carboxy-2,4-dimethyl-5*H*-benzo[*b*][1,4]diazepin-1-ium trifluoroacetate 21b

2,3-Diaminophenol **8** (0.10 g, 0.66 mmol) was used; yield 0.18 g, 83%; mp 177–179 °C; *m*/*z* (HRESI) Found: 217.0977. $C_{12}H_{13}N_2O_2$ requires 217.0970; λ_{max} (H_2O)/nm 278, 318 and 496; λ_{max} (MeOH)/nm 276, 328 and 526; λ_{max} (EtOH)/nm 278, 328 and 532; ν_{max} (KBr)/cm $^{-1}$ 2969, 1688, 1646, 1600, 1547, 1481, 1377, 1274 and 1194; δ_H (200 MHz; DMSO-d_6; Me_4Si) 1.88 (3H, s, CH_3), 1.91 (3H, s, CH_3), 4.62 (1H, s, 3-H), 6.77 (1H, dd, *J* 7.9 and 1.4, 9-H), 7.06 (1H, t, *J* 7.9, 8-H), 7.55 (1H, dd, *J* 7.9 and 1.4, 7-H) and 10.75 (2H, br s, 2 × NH); δ_C (50 MHz; DMSO-d_6; Me_4Si) [33] 12.4 (2 × CH_3), 114.9, 118.8, 124.9, 126.8, 130.1, 132.4, 142.9, 153.6, 158.6 and 165.6; *m*/*z* (EI) 216 (M^+, 20%), 172 (100), 132 (36), 103 (7) and 77 (7).

7-Carboxy-2,4-dimethyl-5*H*-benzo[*b*][1,4]diazepin-1-ium hydrogensulfate 22a

3,4-Diaminobenzoic acid **9** (1.52 g, 10 mmol) was used; yield 2.85 g, 90%; mp 175–178 °C; *m*/*z* (HRESI) Found: 217.0976. $C_{12}H_{13}N_2O_2$ requires 217.0977; λ_{max} (H_2O)/nm 520; λ_{max} (MeOH)/nm 524; λ_{max} (MeCN)/nm 262 and 520; ν_{max} (KBr)/cm $^{-1}$ 3433, 3303, 3069, 3006, 1704, 1640, 1602 and 1478; δ_H (200 MHz; DMSO-d_6; Me_4Si) 1.76 (3H, s, CH_3), 1.78 (3H, s, CH_3), 4.24 (1H, s, 3-H), 6.52 (1H, d, *J* 8.2, 9-H), 7.01 (1H, d, *J* 1.8, 6-H), 7.41 (1H, dd, *J* 8.2 and 1.8, 8-H), 9.71 (1H, s, NH) and 9.90 (1H, s, NH); δ_C (50 MHz; DMSO-d_6; Me_4Si) 24.0 (CH_3), 24.1 (CH_3), 96.2 (CH), 123.2, 124.0, 130.5, 130.6, 133.6, 138.3, 165.2, 175.5 and 176.7; *m*/*z* (EI) 216 (M^+, 100%), 199 (11), 176 (13), 159 (15), 130 (13) and 80 (18).

7-Carboxy-2,4-dimethyl-5*H*-benzo[*b*][1,4]diazepin-1-ium trifluoroacetate 22b

3,4-Diaminobenzoic acid **9** (0.76 g, 5 mmol) was used; yield 0.82 g, 50%; mp 185–187 °C; *m*/*z* (HRESI) Found: 217.0979. $C_{12}H_{13}N_2O_2$ requires 217.0977; λ_{max} (H_2O)/nm 520; λ_{max} (MeOH)/nm 328 and 524; λ_{max} (EtOH)/nm 330 and 524; ν_{max} (KBr)/cm $^{-1}$ 3302, 3019, 1646, 1601, 1477 and 1363; δ_H (200 MHz; DMSO-d_6; Me_4Si) 1.76 (3H, s, CH_3), 1.78 (3H, s, CH_3), 4.24 (1H, s, 3-H), 6.52 (1H, d, *J* 8.2, 9-H), 7.02 (1H, d, *J* 1.8, 6-H), 7.42 (1H, dd, *J* 8.2 and 1.8, 8-H) and 9.84 (2H, br s, 2 × NH); δ_C (50 MHz; DMSO-d_6; Me_4Si) 23.9 (CH_3), 24.0 (CH_3), 96.2 (CH), 123.2, 124.0, 130.6, 130.7, 133.7, 138.3, 165.1, 175.5 and 176.7; *m*/*z* (EI) 216 (M^+, 100%), 199 (11), 171 (12), 159 (12), 130 (16), 69 (21) and 51 (20).

7,7′-Dithiobis(2,4-dimethyl-5*H*-benzo[*b*][1,4]diazepin-1-ium hydrogensulfate) 23a

Bis(3,4-diaminophenyl)disulfide **14** (0.208 g, 0.75 mmol) was used; yield 0.361 g, 87%; mp 170–172 °C; *m*/*z* (HRESI) Found: 407.1368. $C_{22}H_{23}N_4S_2$ requires 407.1372; λ_{max} (H_2O)/nm 536; λ_{max} (MeOH)/nm 270 and 528; λ_{max} (EtOH)/nm 220 and 270; ν_{max} (KBr)/cm $^{-1}$ 3421, 3208, 3049, 2982, 1636, 1592, 1507, 1474 and 1374; δ_H (200 MHz; DMSO-d_6; Me_4Si) 1.78 (12H, s, 2 × CH_3), 4.23 (2H, s, 3-H), 6.49 (2H, d, *J* 8.3, 9-H), 6.61 (2H, d, *J* 1.9, 6-H), 6.99 (2H, dd, *J* 8.3 and 1.9, 8-H), 9.68 (2H, br s, NH) and 9.86 (2H, br s, NH); δ_C (50 MHz; DMSO-d_6; Me_4Si) 24.0 (CH_3), 24.1 (CH_3), 95.9 (CH), 121.4, 124.3, 127.3, 133.2, 135.2, 135.9, 175.8 and 175.9; *m*/*z* (EI) 204 (7%), 64 (100) and 58 (11).

7,7′-Dithiobis(2,4-dimethyl-5*H*-benzo[*b*][1,4]diazepin-1-ium trifluoroacetate) 23b

Bis-(3,4-diaminophenyl)disulfide **14** (0.062 g, 0.223 mmol) was used; yield 0.092 g, 65%; mp 138–142 °C; *m*/*z* (HRESI) Found: 407.1364. $C_{22}H_{23}N_4S_2$ requires 407.1372; λ_{max} (H_2O)/nm 268 and 518; λ_{max} (MeOH)/nm 272 and 528; λ_{max} (EtOH)/nm 270 and 526; ν_{max} (KBr)/cm $^{-1}$ 3418, 3301, 3058, 2559, 1672, 1597, 1506, 1480, 1377, 1202 and 1132; δ_H (200 MHz; DMSO-d_6; Me_4Si) 1.77 (6H, s, 2 × CH_3), 4.21 (1H, s, 3-H), 6.48 (1H, d, *J* 7.7, 9-H), 6.61 (1H, s, 6-H), 6.98 (1H, d, *J* 7.7, 8-H), and 9.96 (2H, br s, 2 × NH); δ_C (50 MHz; DMSO-d_6; Me_4Si) 23.9 (CH_3), 24.0 (CH_3), 95.9 (CH), 121.4, 124.2, 127.2, 133.3, 135.3, 135.9, 175.7 and 175.9; *m*/*z* (EI) 204 (59%), 189 (11), 164 (100), 140 (38), 122 (21), 96 (23), 69 (25) and 51 (16).

General procedure for the preparation of the 2,4-dimethyl-5*H*-benzo[*b*][1,4]diazepine derivatives 24, 25, 26, 32 and 36

A solution of **17b**–**22b** (1 mmol) in water (20 cm^3) was neutralized with 0.1 M NaOH until the color of the solution changed to light yellow. The diimines were extracted with ethyl acetate (2 × 30 cm^3). The combined organic phases were dried over $MgSO_4$ and evaporated *in vacuo* to afford the diimines. Purification of derivative **36** was accomplished by evaporation of the aqueous solution and extraction of the solids with methanol.

6-Hydroxy-2,4-dimethyl-3*H*-benzo[*b*][1,4]diazepine 24

Salt **17b** (0.302 g, 1.0 mmol) was used; yield 0.412 g, 74%; mp 195–198 °C (Found: C, 66.5; H, 6.3; N, 13.7. $C_{11}H_{12}N_2O{\cdot}1/2\ H_2O$ requires C, 66.9; H, 6.6; N, 14.2%); *m*/*z* (HRESI) Found: 189.1029. $C_{11}H_{12}N_2O$ requires 189.1028; ν_{max} (KBr)/cm $^{-1}$ 3159, 2997, 1633, 1560, 1464 and 1446; δ_H (200 MHz; DMSO-d_6; Me_4Si) 2.27 (3H, s, CH_3), 2.32 (3H, s, CH_3), 2.82 (2H, s, CH_2), 6.66 (1H, dd, *J* 8.0 and 1.4, 9-H), 6.73 (1H, dd, *J* 8.0 and 1.4, 7-H), 7.03 (1H, t, *J* 8.0, 8-H) and 8.69 (1H, s, OH); δ_C (50 MHz; DMSO-d_6; Me_4Si) 27.0 (CH_3), 27.1 (CH_3), 43.3 (CH_2), 109.4, 117.4, 124.8, 128.6, 140.6, 152.1, 157.6 and 157.7; *m*/*z* (EI) 188 (M^+, 100%), 173 (41), 148 (39) and 107 (16).

7-Hydroxy-2,4-dimethyl-3*H*-benzo[*b*][1,4]diazepine 25

Salt **18b** (0.302 g, 1.0 mmol) was used; yield 0.165 g, 88%; mp 175–157 °C; *m*/*z* (HRESI) Found: 189.1028. $C_{11}H_{13}N_2O$ requires 189.1020; ν_{max} (KBr)/cm $^{-1}$ 3039, 2783, 1628, 1607, 1555, 1456 and 1379; δ_H (200 MHz; $CDCl_3$; Me_4Si) 2.31 (6H, s, 2 × CH_3), 2.83 (2H, s, CH_2), 6.73 (2H, m, 6,9-H), 7.17 (1H, m, 8-H) and 9.12 (1H, br s, OH); δ_C (50 MHz; $CDCl_3$; Me_4Si) 32.1 (CH_3), 32.2 (CH_3), 47.8 (CH_2), 116.6, 118.9, 133.3, 138.2, 146.1, 158.9, 159.9 and 162.0; *m*/*z* (EI) 189 (M^+ + 1, 100%), 171 (5) and 145 (21).

7-Methoxy-2,4-dimethyl-3*H*-benzo[*b*][1,4]diazepine 26

Salt **19b** (0.316 g, 1.0 mmol) was used; yield 0.16 g, 78% (oily product); *m*/*z* (HRESI) Found: 203.1182. $C_{12}H_{14}N_2O$ requires 203.1184; ν_{max} (film)/cm $^{-1}$ 3380, 2994, 2940, 2907, 1630, 1602, 1549, 1478 and 1438; δ_H (200 MHz; $CDCl_3$; Me_4Si) 2.33 (3H, s, CH_3), 2.34 (3H, s, CH_3), 2.83 (2H, s, CH_2), 3.83 (3H, s, OCH_3), 6.85 (2H, m, 6,9-H) and 7.29 (1H, m, 8-H); δ_C (50 MHz; $CDCl_3$; Me_4Si) 27.5 (CH_3), 27.6 (CH_3), 43.7 (CH_2), 55.4 (OCH_3), 109.1, 114.0, 128.8, 134.3, 141.1, 155.3, 156.4 and 157.2; *m*/*z* (EI) 202 (M^+, 100%), 187 (69), 147 (20) and 119 (8).

7,7′-Dithiobis(2,4-dimethyl-3*H*-benzo[*b*][1,4]diazepine) 32

Salt **20b** (0.32 g, 1.0 mmol) was used; yield 0.20 g, 88%; mp 104–106 °C; *m*/*z* (HRESI) Found: 407.1359. $C_{22}H_{23}N_4S_2$ requires 407.1364; ν_{max} (KBr)/cm $^{-1}$ 3385, 1633, 1585, 1458, 1427, 1288 and 1253; δ_H (200 MHz; $CDCl_3$; Me_4Si) 2.32 (6H, s, CH_3), 2.33 (6H, s, CH_3), 2.82 (4H, s, CH_2), 7.34 (4H, m, 8,9-H), 7.51 (2H, m, 6-H); δ_C (50 MHz; $CDCl_3$; Me_4Si) 27.7 (2 × CH_3), 43.5 (CH_2), 124.2, 126.1, 128.4, 133.1, 139.4, 140.5, 158.0 and 158.5; *m*/*z* (EI) 406 (M^+, 38%), 204 (100), 163 (35), 122 (23), 77 (11) and 63 (10).

Sodium, 2,4-dimethyl-3*H*-benzo[*b*][1,4]diazepine-7-carboxylate 36

Salt **21b** (0.314 g, 1.0 mmol) was used; yield 0.15 g, 63%; mp > 250 °C (decomp.); *m*/*z* (HRESI, cation detection mode) Found:

217.0977. $C_{12}H_{12}N_2O_2$ requires 217.0977; ν_{max} (KBr)/cm $^{-1}$ 3382, 1634, 1582, 1536 and 1384; δ_H (200 MHz; DMSO-d_6; Me_4Si) 2.28 (6H, s, 2 × CH_3), 2.32 (2H, s, CH_2), 7.14 (1H, d, *J* 8.2, 9-H), 7.71 (1H, dd, *J* 8.2 and 1.7, 8-H) and 7.79 (1H, d, *J* 1.7, 6-H); δ_C (50 MHz; DMSO-d_6; Me_4Si) 27.1 (2 × CH_3), 42.8 (CH_2), 125.3, 125.7, 128.0, 136.5, 139.0, 140.4, 157.9, 158.3 and 169.6; *m*/*z* (ESI, anion detection mode) 454.1, 215.1.

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