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Syntheses of Examples of the 5,6-Dihydro-4*H*-[1,2,3]triazolo[4,5,1-*ij*]quinoline, 4,5,6,7-Tetrahydro-[1,2,3]triazolo[4,5,1-*jk*][1,4]benzodiazepine, and 5,6,7,8-Tetrahydro-4*H*-[1,2,3]triazolo[4,5,1-*kl*][1]benzazocine Ring Systems

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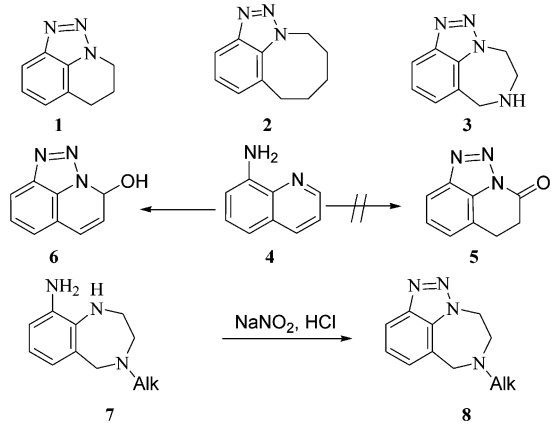
Lithiation of 1-vinylbenzotriazole **9** with *n*-BuLi (2 equiv) generates dianion **10**, which upon subsequent reaction with 1,2- and 1,4-diketones affords **14** and **13**, representatives of the 5,6-dihydro-4*H*-[1,2,3]triazolo[4,5,1-*ij*]quinoline **1** and 5,6,7,8-tetrahydro-4*H*-[1,2,3]triazolo[4,5,1-*kl*][1]benzazocine **2** ring systems, respectively. Reactions of dianion **10** with isocyanates give **15a,b**, which contain the 4,5,6,7-tetrahydro[1,2,3]triazolo[4,5,1-*jk*][1,4]benzodiazepine **3** ring system.

Introduction

The only reported examples of the 4*H*-[1,2,3]triazolo-[4,5,1-*ij*]quinoline ring system **1** are 4-hydroxy-4*H*-[1,2,3]-triazolo[4,5,1-*ij*]quinolines **6**[1] formed from 8-quinolinylamines **4** and originally erroneously formulated as 5,6-dihydro[1,2,3]triazolo[4,5,1-*ij*]quinolin-4-ones **5**.[2]



No previous 5,6,7,8-tetrahydro-4*H*-[1,2,3]triazolo[4,5,1-*kl*][1]benzazocines **2** are recorded, and the only reported 4,5,6,7-tetrahydro[1,2,3]triazolo[4,5,1-*jk*][1,4]benzodiazepines **8** were obtained from 4-alkyl-2,3,4,5-tetrahydro-1*H*-1,4-benzodiazepin-9-ylamines **7** by nitrous acid treatment.[3]

We now describe novel routes to examples of each of the little known ring systems **1**−**3** utilizing the lithiation of 1-vinylbenzotriazole **9** (Scheme 1) followed by reactions with bis-electrophiles or isocyanates. Our previous work in benzotriazole chemistry showed the possibility of double lithiation of certain N-substituted benzotriazoles by deprotonation both at the α-carbon of the N-substituent, and at the 7-position of the benzotriazole ring.[4] Knight et al. reported lithiation at the 7-position of *N*-BOC-protected 1-aminobenzotriazole and trapped the anion with electrophiles in good yields.[5]

We have now lithiated 1-vinylbenzotriazole **9** at the α-carbon of the vinyl group and in the 7-position of the benzotriazole ring (Scheme 1). We examined the reactivity of the dianion formed **10** with 1,2-, 1,3-, and 1,4-dielectrophiles such as 1,2-diphenylethane-1,2-dione **12**, 1,3-diphenyl-1,3-propandione, and hexane-2,5-dione **11**. In cases of the reactions of **10** with **11** and **12**, new eight- and six-membered rings were formed to give 5,8-dimethyl-4-methylene-5,6,7,8-tetrahydro-4*H*-[1,2,3]triazolo-[4,5,1-*kl*][1]benzazocine-5,8-diol **13** and 4-methylene-

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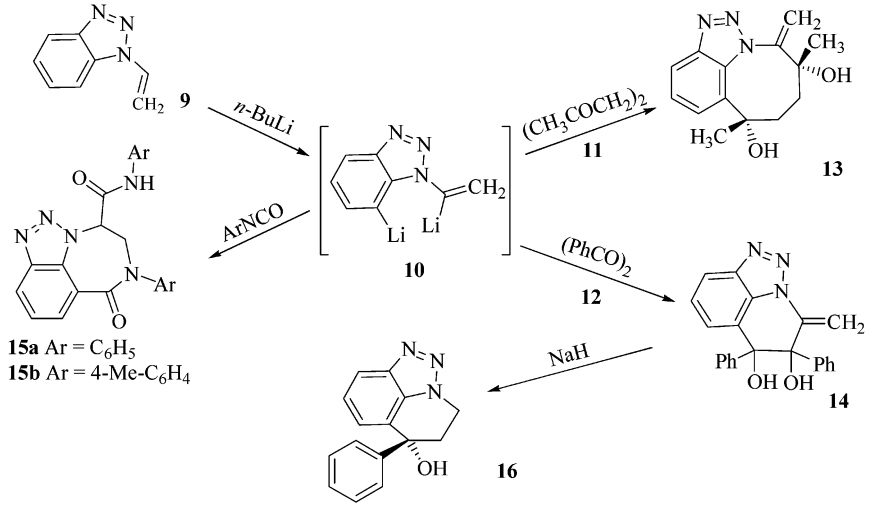
SCHEME 1



5,6-diphenyl-5,6-dihydro-4*H*-[1,2,3]triazolo[4,5,1-*ij*]-quinoline-5,6-diol **14**, respectively. 1,3-Diphenyl-1,3-propandione, due to the acidity of the methylene proton, gives, with dianion **10**, only the product **17** of nucleophilic addition to the vinyl group.

Reactions of **10** with aryl isocyanates give 7-oxo-*N*,6-diaryl-4,5,6,7-tetrahydro[1,2,3]triazolo[4,5,1-*jk*][1,4]benzodiazepine-4-carboxamides **15a**,**b** as a result of the addition of two isocyanate molecules followed by intramolecular nucleophilic addition of the amide nitrogen to the vinyl bond by Michael-type reaction (Scheme 1). We previously reported synthetically useful triazole ring-openings of benzotriazole,[6] but such transformations were not encountered in the present work.

Compound **14** (a mixture of diastereoisomers) gave with an excess of sodium hydride a single 6-phenyl-5,6-dihydro-4*H*-[1,2,3]triazolo[4,5,1-*ij*]quinolin-6-ol **16** (Scheme 3).

Results and Discussion

Compound **9** was dilithiated to **10** with *n*-BuLi (2 equiv) in THF at −78 °C for a period of 10−12 h (optimized conditions). The solution of **10** was treated with 1,2-diphenylethane-1,2-dione **12** at −78 °C to give the triazolo[4,5,1-*ij*]quinoline-5,6-diol **14** as a mixture of two diastereoisomers in almost equivalent amounts in 50% total yield. One diastereoisomer of **14** was separated by crystallization as its hydrate, and an X-ray structure determination confirmed the presence of the [1,2,3]-triazolo[4,5,1-*ij*]quinoline ring system and the (5*R**,6*S**) relative configuration of the substituents of this, the syn-isomer of **14** (Figure 1). The ^{1}H NMR spectrum of **14** shows characteristic signals at 7.5−8.0 ppm corresponding to the 7-substituted benzotriazole ring system. The ^{13}C NMR spectrum shows the disappearance of signals assigned to the benzotriazole ring of **9** around 110 and 124 ppm.

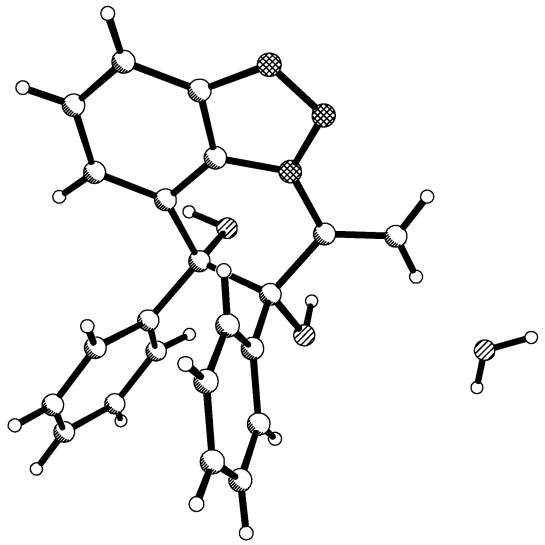


FIGURE 1. Perspective view of the X-ray structure of **14-syn** hydrate.

Treatment of the dianion **10** with hexane-2,5-dione **11** (1 equiv) under the same reaction conditions gave exclusively a single diastereoisomer of the triazolobenzazocine-5,8-diol **13** in 25% yield.

The ^{1}H NMR spectrum of **13** clearly displays two characteristic doublets of doublets at 7.40 and 7.83 ppm and a multiplet at 7.27−7.32 ppm corresponding to the 7-substituted benzotriazole ring system. The two signals at 5.30 and 5.72 ppm are assigned to protons of the 4-methylene group. The set of signals at 1.20−2.40 ppm corresponds to methylene protons of the benzazocine ring and protons of 5,8-methyl groups. The ^{13}C NMR spectrum of **13** shows the absence of signals around 110, 128 ppm and thus proves the absence of a simple non-ring-fused benzotriazole group. A new signal at 154 ppm and a set of signals corresponding to an alkyl chain of the six carbons at 30, 33, 35, 38, 73, and 74 ppm support structure **13**. Structure **13** was confirmed by the X-ray crystallographic analysis, which confirmed the overall structure and determined the (5*R**,8*S**)-diastereoisomeric structure (Figure 2).

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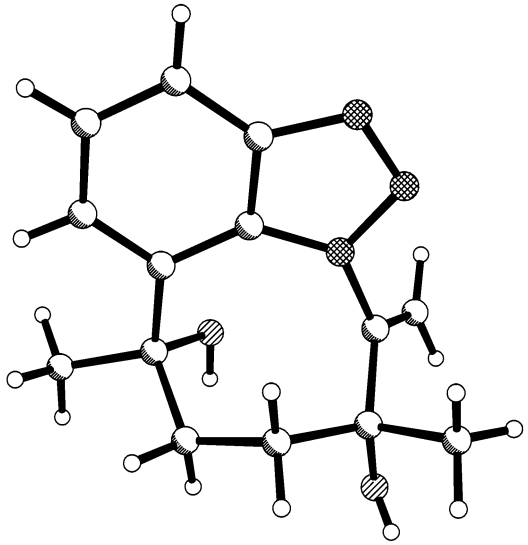


FIGURE 2. Perspective view of the X-ray structure of **13**.

Dianion **10** was treated with 2 equiv of phenyl isocyanate in THF at −78 °C for 2 h to give 7-oxo-*N*,6-diphenyl-4,5,6,7-tetrahydro[1,2,3]triazolo[4,5,1-*jk*][1,4]-benzodiazepine-4-carboxamide **15a** (65%). The use of 4-methylphenyl isocyanate similarly gave benzodiazepine-4-carboxamide **15b** (65%) (Scheme 1).

The structures of **15a** and **15b** were deduced from their NMR spectra. The ^{1}H NMR spectrum of **15b** shows signals of only three benzotriazole protons in the range of 7.60−8.50 ppm and a set of signals of C-4, C-5 protons (a doublet of doublets on 4.69 ppm, a doublet on 4.78 ppm, and a singlet on 6.11 ppm). The ^{13}C NMR spectrum shows new signals at 169 and 170 ppm, which are assigned to amide carbons of **15b**; signals at 148 and 151 ppm; and no olefinic carbons signals.

Dianion **10** was reacted with 1,3-diphenyl-1,3-propandione (1 equiv) (under the same conditions as previously described for the preparation of **13**) to give 2-[2-(benzotriazol-1-yl)ethyl]-1,3-diphenyl-1,3-propanedione **17** in 40% yield (Scheme 2). Compound **17** is the product of nucleophilic addition of 1,3-propandione anion to the vinyl group of **10**; the transformation of **10** to **17** reflects the high acidity of the C-2 protons in 1,3-diphenyl-1,3-propandione. Structure **17** was deduced from its NMR spectra; it shows no olefin signals in either the ^{1}H or the ^{13}C NMR spectrum. The signals in the ^{1}H NMR spectrum at 2.8−3.1 ppm correspond to 2-(benzotriazol-1-yl)ethyl group in position 2 of the 1,3-propanedione **17**. The ^{13}C NMR spectrum also shows two signals of carbonyl groups at 194 and 199 ppm.

The reaction of dianion **10** with 2 equiv of 4-methylbenzaldehyde gave 2-[7-[hydroxy(4-methylphenyl)methyl]-1*H*-benzotriazol-1-yl]-1-(4-methylphenyl)-2-propen-1-ol **19** (Scheme 2) as an equal mixture of two diastereoisomers in overall 80% yield. The ^{1}H NMR spectrum of **19** displays singlets at 6.51 and 5.57 ppm and doublets at 6.26 and 5.57 ppm corresponding to four methine protons of **19**. A set of three singlets at 5.48, 5.36, and 5.14 ppm is assigned to the four olefinic protons, and a set of three singlets at 2.35, 2.31, and 2.29 ppm to the methyl protons of the 4-methylphenyl groups. The ^{13}C NMR spectrum also supports the structure assigned to **19**.

Similar reaction of dianion **10** with 2 equiv of (*E*)-1,3-diphenyl-2-propen-1-one gave (*E*)-4-[7-[(*E*)-1-hydroxy-1,3-diphenyl-2-propenyl]-1*H*-benzotriazol-1-yl]-1,3-diphenyl-1,4-pentadien-3-ol **20** as a single diastereoisomer in 40% yield. The structure of **20** was established from its NMR spectra. The ^{1}H NMR spectrum of **20** shows two broad singlets at 4.15 and 5.33 ppm, a set of four doublets of the trans-olefinic protons at 6.03, 6.42, 6.61, and 6.83 ppm, and two singlets at 5.19 and 5.66 ppm assigned to the β-protons of the vinyl group. The ^{13}C NMR spectrum shows the signals of two carbinol carbons at 79.8 and 80.6 ppm and the rest of the signals are in the range of 120−147 ppm. No 4,7-disubstituted 4,5-dihydro-7*H*-[1,2,3]-triazolo[4,5,1-*jk*][4,1]benzoxazepines **18** (Scheme 2) were observed in either case as possible products of cyclization by Michael addition of the oxygen anion to the vinyl group.

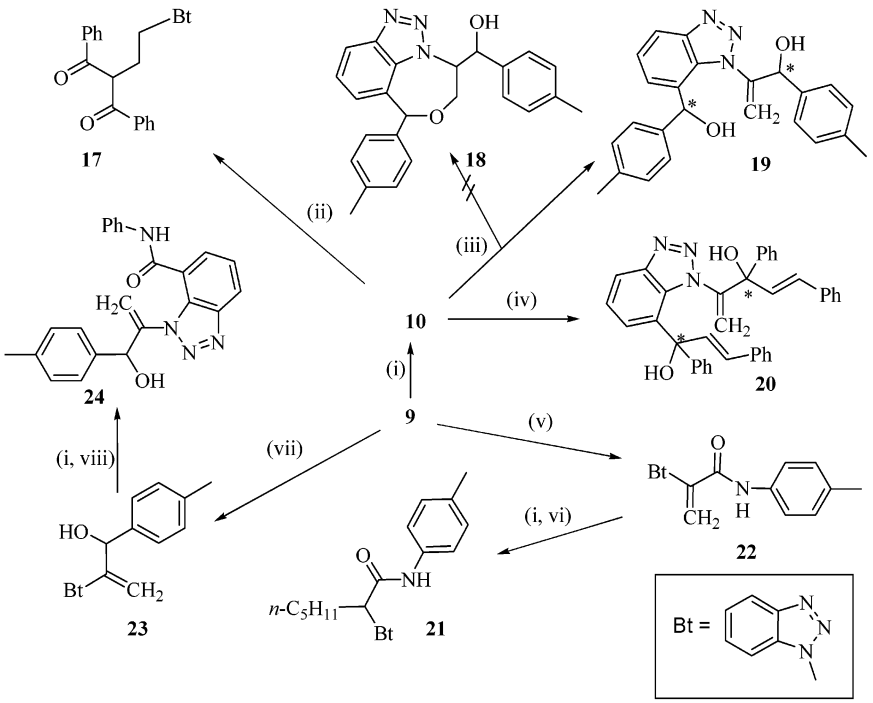
We prepared α-protected 2-(benzotriazol-1-yl)-*N*-(4-methylphenyl)acrylamide **22** by lithiation of **9** with *n*-BuLi (1 equiv) in THF at −78 °C followed by addition of 4-methylphenyl isocyanate. The ^{1}H NMR spectrum of **22** shows a singlet at 2.32 ppm corresponding to the methyl protons of the 4-methylphenyl group, two singlets at 6.06 and 6.81 ppm assigned to the two β-protons of the vinyl bond, and a broad singlet of the amide proton at 8.82 ppm. The ^{13}C NMR spectrum also confirms the structure of **22** and shows the amide carbon signal at 158.7 ppm.

Attempted lithiation of **22** with 2 equiv of *n*-BuLi in THF at −78 °C followed by treatment with 4-methylbenzaldehyde gave only addition of *n*-BuLi to the C=C bond of acrylamide **22** to afford 2-(benzotriazol-1-yl)-*N*-(4-methylphenyl)heptanamide **21** in 40% yield. The structure of **21** was deduced from its ^{1}H and ^{13}C NMR spectra. The ^{1}H NMR spectrum of **21** shows a set of signals at 7.2−8.0 ppm characteristic for an N-substituted benzotriazole and signals for the heptanamide alkyl chain **21** in regions 0.78 ppm, 1.1−1.3 ppm, 2.4−2.5 ppm, and 5.6 ppm. The ^{13}C spectrum also shows the characteristic pattern for N-substituted 1*H*-benzotriazoles around 110, 120, 124, 128, 133, and 146 ppm, together with alkyl chain signals at 13.8, 22.2, 25.5, 30.9, 32.0, and 64.6 ppm and the signal of the amide carbon at 166.3 ppm.

The lithiation of **9** with 1 equiv of *n*-BuLi in THF at −78 °C followed by addition of 4-methylbenzaldehyde gave 2-(benzotriazol-1-yl)-1-(4-methylphenyl)-2-propen-1-ol **23** in 60% yield. The ^{1}H NMR spectrum of **23** shows signals assigned to the benzotriazole ring protons in the range of 7.30−8.00 ppm, doublets at 3.88 and 6.10 ppm. A multiplet in the range of 5.61−5.68 ppm is assigned to the 2-propen-1-ol part of **23**. The ^{13}C NMR spectrum also supports the structure of **23**.

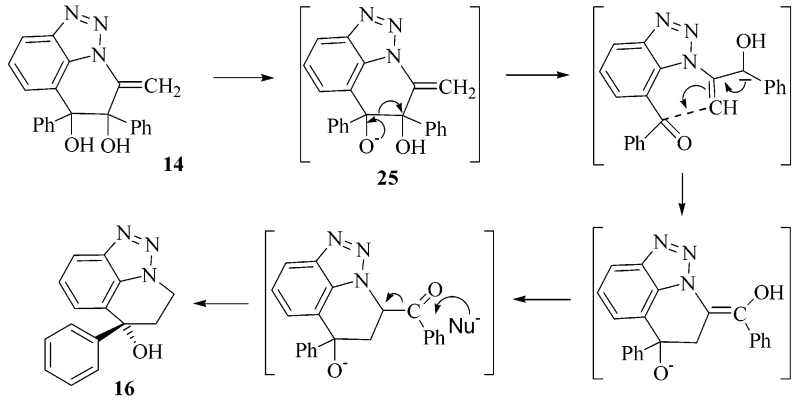
The lithiation of the 7-position of the benzotriazole ring in 2-(1*H*-benzotriazol-1-yl)-1-(4-methylphenyl)-2-propen-1-ol **23** with 2 equiv of *n*-BuLi in THF at −78 °C followed by reaction with phenyl isocyanate gave 1-[1-[hydroxy-(4-methylphenyl)methyl]vinyl]-*N*-phenyl-1*H*-benzotriazole-7-carboxamide **24** and no products of cyclization. The ^{1}H NMR spectrum of **24** shows signals assigned to protons of the 2-propen-1-ol fragment in the range of 5.69−6.11 ppm, the amide proton signal at 11.16 ppm, and the characteristic set of signals in the range of 7.59−8.20 ppm of 7,*N*-disubstituted benzotriazole. The ^{13}C NMR spectrum also supports the structure of **24** and

SCHEME 2[a]



[a] Key: (i) *n*-BuLi, 2 equiv, THF, −78 °C, 12 h; (ii) $(PhCO)_2CH_2$, THF, −78 °C, 2 h; (iii) 4-$CH_3C_6H_4CHO$, THF, −78 °C, 2 h; (iv) PhCOCH=CHPh, THF, −78 °C, 2 h; (v) *n*-BuLi, 1 equiv, 4-$CH_3C_6H_4CHO$, THF, −78 °C, 4 h; (vi) 4-$CH_3C_6H_4CHO$, THF, −78 °C, 2 h; (vii) *n*-BuLi, 1 equiv, 4-$CH_3C_6H_4CHO$, THF, −78 °C, 12 h; (viii) PhNCO, THF, −78 °C, 2 h.

SCHEME 3



shows the amide carbon signal at 160.2 ppm and only signals at 71.8 and 19.8 ppm in the aliphatic region of the spectrum.

It is probable that the presence of electron-donating α-substituents in **19**, **20**, and **24** dramatically decrease the reactivity of the vinyl group.

Treatment of the diol **14** (mixture of diastereoisomers) with sodium hydride (4 equiv) in 1,4-dioxane under reflux led to a single product, 6-phenyl-5,6-dihydro-4*H*-[1,2,3]-triazolo[4,5,1-*ij*]quinolin-6-ol **16**. The reaction mechanism may involve deprotonation of the hydroxyl group at C-6 to give anion **25**, which undergoes ring-opening and -reclosure transformations to afford **16** (Scheme 3).

The structure of **16** was deduced from its ^{1}H and ^{13}C NMR spectra. The ^{1}H NMR spectrum of **16** clearly displays two characteristic doublets of doublets at 7.91 and 7.09 ppm and a multiplet at 7.28−7.47 ppm corresponding to the 6-phenyl group and 7-substituted benzotriazole ring system. A set of signals at 4.70−4.90 ppm and 2.55−2.60 ppm correspond to methylene protons of 5,6-dihydro-4*H*-[1,2,3]triazolo[4,5,1-*ij*]quinoline ring system. The ^{13}C NMR spectrum also supports the structure of **16**. Finally, the structure **16** was confirmed by the X-ray crystallography (Figure 3).

Conclusion

The double lithiation of 1-vinylbenzotriazole followed by reaction with bis-electrophiles and isocyanates opens up new routes to diverse heterocyclic ring systems.

Experimental Section

General Methods. Melting points were determined on a hot-stage apparatus and are uncorrected. NMR spectra were recorded in $CDCl_3$, acetone-d_6, or DMSO-d_6 with TMS as the internal standard for ^{1}H (300 MHz) or a solvent as the internal

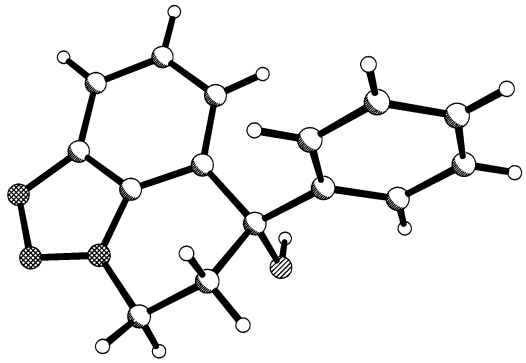


FIGURE 3. Perspective view of the X-ray structure of **16**.

standard for ^{13}C (75 MHz). Microanalyses were performed on an EA-1108 elemental analyzer. THF was dried over sodium/benzophenone and used freshly distilled. Column chromatography was conducted on silica gel 200−425 mesh.

The 1-vinyl-1*H*-benzotriazole **9** was prepared according to the published procedure in 45% yield.[7]

General Procedure for the Preparation of Dianion (10) Solution. A stirred solution of 1-vinyl-1*H*-benzotriazole **9** (0.5 g, 3.45 mmol) in THF (50 mL) was cooled to −78 °C, and a solution of *n*-BuLi (4.38 mL, 7.0 mmol, 1.6 M in hexanes) was added dropwise. The reaction mixture was stirred at this temperature for 12 h and then treated with an appropriate electrophile at the same temperature.

General Procedure for the Preparation of 13 and 14. A solution of diketone **11** or **12** (4.0 mmol) in THF (15 mL) was added dropwise to a stirred solution of dianion **10** (3.45 mmol) at −78 °C (for the preparation of **10** see above). The reaction mixture was stirred at this temperature for 2 h and then for an additional 2 h at 20−25 °C. Then, water was added, and the product was extracted with diethyl ether. The extract was washed with water, dried over anhydrous magnesium sulfate, and evaporated under reduced pressure. The residue was purified by column chromatography on silica gel to give **13** or **14**.

(5*R,8*S**)-5,8-Dimethyl-4-methylene-5,6,7,8-tetrahydro-4*H*-[1,2,3]triazolo[4,5,1-*kl*][1]benzazocine-5,8-diol (13):** plates from methylene chloride (25%); mp 194−195 °C; ^1H NMR ($CDCl_3$) δ 7.82 (dd, J = 8.2, 1.0 Hz, 1H), 7.40 (dd, J = 7.4, 0.8 Hz, 1H), 7.32−7.27 (m, 1H), 5.72 (s, 1H), 5.30 (d, J = 1.0 Hz, 1H), 4.00 (s, 1H), 3.55 (d, J = 1.8 Hz, 1H), 2.42−2.31 (m, 1H), 1.85 (s, 3H), 1.61−1.48 (m, 2H), 1.44 (s, 3H), 1.38−1.26 (m, 1H); ^{13}C NMR ($CDCl_3$):δ 154.1, 146.3, 132.5, 129.8, 124.2, 123.9, 119.4, 111.8, 74.3, 73.3, 38.2, 35.1, 33.5, 30.0. Anal. Calcd for $C_{14}H_{17}N_3O_2$: C, 64.85; H, 6.61; N, 16.20. Found: C, 63.99; H, 6.59; N, 15.98.

Crystal data for 13: $C_{14}H_{17}N_3O_2$, FW 259.31, monoclinic, space group $P2_1/n$, a = 11.820(3) Å, b = 8.750(2) Å, c = 12.761(3) Å, β = 104.446(4)°, V = 1278.1(5) Å^3, $F(000)$ = 552, Z = 4, T = −105 °C, μ (Mo Kα) = 0.092 mm^{-1}, D_{calcd} = 1.348 g cm^{-3}, crystal size 0.83 × 0.59 × 0.05 mm, $2\theta_{max}$ 50° (CCD area detector, Mo Kα radiation, 99.9% completeness), GOF = 0.89, $wR(F^2)$ = 0.0901 (all 2249 data), R = 0.0386 (1419 data with $I > 2\sigma I$).

4-Methylene-5,6-diphenyl-5,6-dihydro-4*H*-[1,2,3]triazolo[4,5,1-*ij*]quinoline-5,6-diol (mixture of two diastereoisomers) (14): microcrystals from acetone (50%); mp 195−198 °C; ^1H NMR (acetone-d_6) δ 8.00 (d, J = 8.4 Hz, 1H), 7.94 (d, J = 8.4 Hz, 1H), 7.45−7.29 (m, 5H,), 7.26−7.06 (m, 12 H), 7.05−6.90 (m, 3H), 6.65 (br s, 2H), 6.24 (dd, J = 5.3, 1.3 Hz, 2H), 5.62 (s, 1H), 5.48 (s, 1H), 5.40 (s, 1H), 5.34 (d, J = 0.8 Hz, 2H), 5.02 (d, J = 1.3 Hz, 1H); ^{13}C NMR (acetone-d_6) δ 145.8, 145.4, 145.3, 140.1, 139.5, 131.5, 131.3, 130.4, 129.4, 128.7, 128.6, 128.4, 128.0, 127.5, 127.7, 126.5, 126.0, 125.9, 119.6, 119.3, 103.6, 103.2, 82.3, 82.2, 81.1, 80.3. Anal. Calcd for $C_{22}H_{19}N_3O_3$: C, 70.76; H, 5.13; N, 11.25. Found: C, 71.14; H, 5.45; N, 11.33.

(5*R,6*S**)-4-Methylene-5,6-diphenyl-5,6-dihydro-4*H*-[1,2,3]triazolo[4,5,1-*ij*]quinoline-5,6-diol (14-syn):** prisms from acetone (25%); mp 209−210 °C; ^1H NMR (acetone-d_6): δ 8.00 (d, J = 8.3 Hz, 1H), 7.46−7.40 (m, 1H), 7.31 (d, J = 7.0 Hz, 1H), 7.25−7.06 (m, 5H), 7.05−6.90 (m, 3H), 6.65 (br s, 2H), 6.23 (s, 1H), 5.62 (s, 1H), 5.48 (s, 1H), 5.41 (s, 1H); ^{13}C NMR (acetone-d_6) δ 145.1, 140.1, 131.2, 129.1, 128.4, 128.0, 127.6, 126.4, 126.2, 119.3, 102.8, 82.0, 80.8. Anal. Calcd for $C_{22}H_{19}N_3O_3$: C, 70.76; H, 5.13; N, 11.25. Found: C, 71.14; H, 5.45; N, 11.33.

Crystal data for 14-syn: $C_{22}H_{19}N_3O_3$, FW 373.40, triclinic, space group P-1, a = 8.705(2) Å, b = 9.997(3) Å, c = 11.937(3) Å, α = 71.392(4)°, β = 69.516(3)°, γ = 78.609(3)°, V = 918.0(4) Å^3, $F(000)$ = 392, Z = 2, T = −105 °C, μ (Mo Kα) = 0.092 mm^{-1}, D_{calcd} = 1.351 g cm^{-3}, crystal size 0.68 × 0.67 × 0.19 mm, $2\theta_{max}$ 46° (CCD area detector, Mo Kα radiation, 99.5% completeness), GOF = 1.14, $wR(F^2)$ = 0.1287 (all 2542 data), R = 0.0537 (2236 data with $I > 2\sigma I$).

General Procedure for the Preparation of [1,4]Benzodiazepines 15a and 15b. The solution of phenyl or 4-methylphenyl isocyanate (8.0 mmol) in THF (15 mL) was added dropwise to a stirred solution of dianion **10** (3.45 mmol) at −78 °C (for the preparation of **10** see above). The reaction mixture was stirred at this temperature for 2 h and then for an additional 2 h at 20−25 °C. Then, water was added slowly at 0−5 °C. The precipitate was filtered off, washed with water, and dried in a vacuum. The product was purified by recrystallization from acetone to give the corresponding pure product **15**.

7-Oxo-*N*,6-diphenyl-4,5,6,7-tetrahydro[1,2,3]triazolo-[4,5,1-*jk*][1,4]benzodiazepine-4-carboxamide (15a): microcrystals from acetone (65%), mp >260 °C; ^1H NMR (DMSO-d_6−$CDCl_3$) δ 10.2 (s, 1H), 8.33 (d, J = 7.4 Hz, 1H), 8.28 (d, J = 8.2 Hz, 1H), 7.65−7.50 (m, 1H), 7.40−7.00 (m, 10H), 6.15 (d, J = 3.8 Hz, 1H), 4.92 (dd, J = 16.0, 4.6 Hz, 1H), 4.55 (d, J = 16.0 Hz, 1H); ^{13}C NMR (DMSO-d_6−$CDCl_3$) δ 164.8, 163.1, 145.0, 143.7, 136.7, 131.2, 129.6, 128.2, 127.8, 126.3, 126.0, 123.5, 123.4, 123.3, 119.1, 115.7, 62.0, 52.0. Anal. Calcd for $C_{22}H_{17}N_5O_2 \cdot 1H_2O$: C, 65.83; H, 4.77; N, 17.45. Found: C, 66.27; H, 4.98; N, 17.49.

***N*,6-Bis(4-methylphenyl)-7-oxo-4,5,6,7-tetrahydro[1,2,3]-triazolo[4,5,1-*jk*][1,4]benzodiazepine-4-carboxamide (15b):** microcrystals from methanol (65%); mp >260 °C; ^1H NMR (DMSO-d_6) δ 10.4 (s, 1H), 8.42 (d, J = 8.4 Hz, 1H), 8.25 (d, J = 7.2 Hz, 1H), 7.66−7.61 (m, 1H), 7.26 (d, J = 8.2 Hz, 2H), 7.10 (d, J = 8.2 Hz, 2H), 7.03 (s, 4H) 6.11 (s, 1H), 4.77 (d, J = 15.6 Hz, 1H), 4.68 (dd, J = 15.6, 4.4 Hz, 1H), 2.25 (s, 3H), 2.23 (s, 3H); ^{13}C NMR (DMSO-d_6) δ 170.3, 169.3, 150.7, 147.6, 141.3, 140.3, 138.4, 136.7, 135.5, 134.6, 134.4, 131.9, 129.6, 129.1, 125.0, 121.9, 67.8, 57.8, 25.8, 25.7. Anal. Calcd for $C_{24}H_{21}N_5O_2 \cdot 1H_2O$: C, 67.12; H, 5.40; N, 16.31. Found: C, 67.28; H, 5.57; N, 16.39.

Procedure for the Preparation of 6-Phenyl-5,6-dihydro-4*H*-[1,2,3]triazolo[4,5,1-*ij*]quinolin-6-ole (16). A mixture of two diastereoisomers of **14** (0.2 g, 0.56 mmol) with sodium hydride (0.054 g, 2.24 mmol) in 1,4-dioxane (10 mL) was refluxed for 1 h. The reaction mixture was quenched with a saturated aqueous ammonium chloride. The product was extracted with ethyl acetate. The extract was washed with water, dried over anhydrous magnesium sulfate, and evaporated under reduced pressure. The residue was purified by recrystallization from methanol to give **16** (0.112 g, 80%). Needles from methanol: mp 208−209 °C; ^1H NMR ($CDCl_3$) δ 7.91 (dd, J = 8.4, 0.7 Hz, 1H), 7.47−7.28 (m, 6H), 7.09 (dd, J = 7.0, 0.6 Hz, 1H), 5.17 (s, 1H), 4.90−4.70 (m, 2H), 2.60−2.55 (m, 2H); ^{13}C NMR ($CDCl_3$) δ 143.8, 143.2, 131.5, 128.0, 127.5, 126.8, 125.5, 124.1, 122.4, 117.4, 71.1, 42.4, 39.3 Anal. Calcd

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for $C_{15}H_{13}N_3O$: C, 71.70; H, 5.21; N, 16.72. Found: C, 71.54; H, 5.37; N, 15.97.

Crystal data for 16: $C_{15}H_{13}N_3O$, FW 251.28, monoclinic, space group $P2_1/c$, $a = 13.346(7)$ Å, $b = 7.723(4)$ Å, $c = 13.247(7)$ Å, $\beta = 116.802(3)°$, $V = 1219(1)$ Å^3, $F(000) = 528$, $Z = 4$, $T = -105$ °C, μ (Mo Kα) = 0.089 mm^{-1}, $D_{calcd} = 1.370$ g cm^{-3}, crystal size 0.83 × 0.49 × 0.05 mm, $2\theta_{max}$ 50° (CCD area detector, Mo Kα radiation, 98.8% completeness), GOF = 0.96, wR(F^2) = 0.1495 (all 2124 data), $R = 0.0528$ (1312 data with $I > 2\sigma I$).

Procedure for the Preparation of 2-[2-(Benzotriazol-1-yl)ethyl]-1,3-diphenyl-1,3-propanedione (17). A solution of 1,3-diphenyl-1,3-propanedione (0.9 g, 4.0 mmol) in THF (15 mL) was added dropwise to a stirred solution of dianion **10** (3.45 mmol) at −78 °C (for the preparation of **10** see above). The reaction mixture was stirred at this temperature for 2 h and then for an additional 2 h at 20−25 °C. Then, water was added, and the product was extracted with diethyl ether. The extract was washed with water, dried over anhydrous magnesium sulfate, and evaporated under reduced pressure. The residue was purified by column chromatography on silica gel to give **17** as an oil (0.51 g, 40%): ^{1}H NMR ($CDCl_3$):δ 8.17−8.14 (m, 2H), 8.04 (d, J = 8.4 Hz, 1H), 7.85−7.82 (m, 2H), 7.61−7.30 (m, 9H), 6.84 (dd, J = 10.5, 4.0 Hz, 1H), 3.10−2.79 (m, 4H); ^{13}C NMR ($CDCl_3$) δ 198.7, 193.6, 146.5, 136.2, 134.2, 134.1, 133.2, 132.4, 128.9, 128.9, 128.6, 127.9, 127.8, 124.2, 120.2, 110.4, 62.6, 33.8, 24.5. Anal. Calcd for $C_{23}H_{19}N_3O_2$: C, 74.78; H, 5.18; N, 11.37. Found: C, 74.39; H, 5.23; N, 11.82.

General Procedure for the Preparation of 19 and 20. A solution of 1-vinylbenzotriazole (0.5 g, 3.45 mmol) in THF (50 mL) was cooled to −78 °C, and a solution of *n*-BuLi (8.00 mmol, 1.58 M in hexane, 5.1 mL) was added dropwise. The reaction mixture was stirred at the same temperature for 12 h, and a solution of 4-methylbenzaldehyde or (*E*)-1,3-diphenyl-2-propen-1-one (8.00 mmol) in THF (15 mL) was added. The mixture was stirred for an additional 2 h at −78 °C and then 2 h at room temperature and quenched with water. The product was extracted with ether, and the extract was dried over magnesium sulfate and evaporated to dryness under reduced pressure. The residue was purified by gradient column chromatography using mixtures of hexanes and ethyl acetate (8:1−2:1) to give **19** or **20**.

2-[7-[Hydroxy(4-methylphenyl)methyl]benzotriazol-1-yl]-1-(4-methylphenyl)-2-propen-1-ol (mixture of diastereoisomers) (19): microcrystals (80%); mp 78−80 °C; ^{1}H NMR ($CDCl_3$) δ 7.77 (d, J = 8.0 Hz, 1H), 7.60 (d, J = 8.0 Hz, 1H), 7.33 (d, J = 7.9 Hz, 2H), 7.27−6.90 (m, 18 H), 6.51 (s, 1H), 6.26−6.25 (m, 1H), 5.79 (d, J = 4.1 Hz, 1H), 5.57 (s, 1H), 5.48 (s, 3H), 5.36 (s, 1H), 5.14 (s, 1H), 4.90 (s, 1H), 4.38 (d, J = 4.0 Hz, 1H), 3.73 (s, 1H), 2.35 (s, 6H), 2.31 (s, 3H), 2.29 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 147.7, 146.5, 145.6, 145.3, 138.8, 138.1, 137.9, 137.4, 137.3, 136.5, 136.2, 132.2, 131.8, 129.3, 129.1, 129.0, 128.4, 128.2, 128.1, 127.4, 126.9, 126.8, 126.7, 126.6, 126.5, 124.4, 124.2, 119.2, 118.8, 117.7, 75.4, 70.1, 68.5, 21.2, 21.1. Anal. Calcd for $C_{24}H_{23}N_3O_2$: C, 74.78; H, 6.01; N, 10.90. Found: C, 74.76; H, 5.85; N, 10.93.

4-[7-[(1,3-Diphenyl-1-hydroxy-2-propenyl]-benzotriazol-1-yl]-1,3-diphenyl-1,4-pentadien-3-ol (20): microcrystals from acetone (40%); mp 130−132 °C; ^{1}H NMR ($CDCl_3$) δ 7.97 (d, J = 8.2 Hz, 1H), 7.67−7.40 (m, 3H), 7.35−7.05 (m, 19H), 6.84 (d, J = 15.7 Hz, 1H), 6.60 (d, J = 15.9 Hz, 1H), 6.42 (d, J = 15.9 Hz, 1H), 6.00 (d, J = 15.9 Hz, 1H), 5.66 (s, 1H), 5.33 (br s, 1H), 5.20 (s, 1H), 4.15 (br s, 1H); ^{13}C NMR ($CDCl_3$) δ 146.8, 144.4, 136.5, 135.8, 135.3, 134.2, 132.8, 131.5, 130.7, 128.8, 128.6, 128.5, 128.1, 127.9, 127.8, 127.6, 127.4, 127.0, 126.8, 126.7, 123.0, 120.7, 80.6, 79.7. Anal. Calcd for $C_{38}H_{31}N_3O_2$: C, 81.26; H, 5.56; N, 7.48. Found: C, 81.02; H, 5.19; N, 7.14.

Procedure for the Preparation of 2-(Benzotriazol-1-yl)-*N*-phenylheptanamide (21). A solution of 2-(benzotriazol-1-yl)-*N*-(4-methylphenyl)acrylamide **22** (0.5 g, 1.8 mmol) in THF (50 mL) was cooled to −78 °C, and a solution of *n*-BuLi (4.0 mmol, 1.6 M in hexane, 2.5 mL) was added dropwise. The reaction mixture was stirred at this temperature for 12 h, and a solution of 4-methylbenzaldehyde (0.24 g, 2.00 mmol) in THF (15 mL) was added. The reaction mixture was stirred for an additional 2 h at −78 °C and 2 h at 20−25 °C. Then, water was added and the product was extracted with diethyl ether. The extract was washed with water, dried over anhydrous magnesium sulfate, and evaporated under reduced pressure. The residue was purified by column chromatography on silica gel to give **21** (0.24 g, 40%): microcrystals from acetone; mp 106−107 °C; ^{1}H NMR ($CDCl_3$) δ 8.71 (s, 1H), 8.03 (d, J = 8.4 Hz, 1H), 7.77 (d, J = 8.4 Hz, 1H), 7.55−7.48 (m, 1H), 7.42−7.36 (m, 3H), 7.06 (d, J = 8.2 Hz, 2H), 5.60 (dd, J = 8.7, 6.7 Hz, 1H), 2.54−2.43 (m, 2H), 2.27 (s, 3H), 1.37−1.05 (m, 6H), 0.78 (t, J = 6.9 Hz, 3H); ^{13}C NMR ($CDCl_3$) δ 166.3, 146.01, 134.6, 134.4, 133.0, 129.4, 128.1, 124.6, 120.3, 119.9, 110.5, 64.6, 32.0, 30.9, 25.5, 22.2, 20.8, 13.8. Anal. Calcd for $C_{20}H_{24}N_4O$: C, 71.40; H, 7.19; N, 16.65. Found: C, 71.58; H, 7.50; N, 16.25.

Procedure for the Preparation of 2-(Benzotriazol-1-yl)-*N*-(4-methylphenyl)acrylamide (22). 1-Vinylbenzotriazole **9** (0.5 g, 3.45 mmol) in THF (50 mL) was cooled to −78 °C, and a solution of *n*-BuLi (3.5 mmol, 1.6 M in hexane, 2.2 mL) was added dropwise. The solution was stirred at this temperature for 2 h and 4-methylphenylisocyanate (0.48 g, 4.0 mmol) in THF (15 mL) was added. The reaction mixture was stirred for an additional 2 h at −78 °C and 2 h at 20−25 °C. Then, water was added and the product was extracted with diethyl ether. The extract was washed with water, dried over anhydrous magnesium sulfate, and evaporated under reduced pressure. The residue was purified by column chromatography on silica gel to give **22** (0.62 g, 65%): needles from acetone; mp 125−126 °C; ^{1}H NMR ($CDCl_3$) δ 8.82 (s, 1H), 8.10 (d, J = 8.4 Hz, 1H), 7.61−7.59 (m, 2H), 7.50−7.40 (m, 3H), 7.13 (d, J = 8.4 Hz, 2H), 6.81 (s, 1H), 6.06 (s, 1H), 2.32 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 158.7, 145.7, 137.0, 135.0, 134.3, 133.2, 129.5, 129.2, 125.1, 120.7, 120.6, 120.3, 110.6, 20.9. Anal. Calcd for $C_{16}H_{14}N_4O$: C, 69.05; H, 5.07; N, 20.13. Found: C, 69.18; H, 5.45; N, 20.04.

Procedure for the Preparation of 2-(Benzotriazol-1-yl)-1-(4-methylphenyl)-2-propen-1-ol (23). 1-Vinylbenzotriazole **9** (0.5 g, 3.45 mmol) in THF (50 mL) was cooled to −78 °C, and solution of *n*-BuLi (2.2 mL, 3.5 mmol, 1.6 M in hexane) was added dropwise. The solution was stirred at this temperature for 2 h, and 4-methylbenzaldehyde (0.37 g, 3.5 mmol) in THF (15 mL) was added. The reaction mixture was stirred for an additional 3 h at −78 °C. Then, brine was added, and the product was extracted with diethyl ether. The extract was washed with water, dried over anhydrous magnesium sulfate, and evaporated under reduced pressure. The residue was purified by column chromatography on silica gel to give **23** (0.55 g, 60%): needles from acetone; mp 95−96 °C; ^{1}H NMR ($CDCl_3$) δ 8.00−7.97 (m, 1H), 7.60−7.56 (m, 1H), 7.49−7.43 (m, 1H), 7.38−7.23 (m, 3H), 7.02 (d, J = 8.2 Hz, 2H), 6.10 (d, J = 5.2 Hz, 1H), 5.68−5.62 (m, 2H), 3.87 (d, J = 5.4 Hz, 1H), 2.23 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 21.0, 74.0, 108.0, 110.8, 120.0, 124.4, 126.5, 128.2, 129.1, 132.4, 136.6, 137.9, 145.3, 145.5. Anal. Calcd for $C_{16}H_{15}N_3O$: C, 72.43; H, 5.70; N, 15.84. Found: C, 72.82; H, 5.48; N, 16.15.

Procedure for the Preparation of 1-[1-[Hydroxy(4-methylphenyl)methyl]vinyl]-*N*-phenyl-1*H*-benzotriazole-7-carboxamide (24). A solution of 2-(benzotriazol-1-yl)-1-(4-methylphenyl)-2-propen-1-ol **23** (0.56 g, 2.1 mmol) in THF (50 mL) was cooled to −78 °C, and a solution of *n*-BuLi (4.7 mmol, 1.6 M in hexane, 2.9 mL) was added dropwise. The solution was stirred at this temperature for 12 h and phenyl isocyanate (0.56 g, 4.7 mmol) in THF (15 mL) was added. The reaction mixture was stirred for an additional 2 h at −78 °C and 2 h at 20−25 °C. Then, brine was added, and the product was extracted with diethyl ether. The extract was washed with water, dried over anhydrous magnesium sulfate, and evapor-

ated under reduced pressure. The residue was purified by column chromatography on silica gel to give **24** (0.28 g, 35%): microcrystals from acetone; mp 137 °C; ^{1}H NMR ($CDCl_3$) δ 11.16 (s, 1H), 8.19 (d, J = 7.1 Hz, 1H), 7.84−7.79 (m, 3H), 7.65−7.60 (m, 1H), 7.41−7.38 (m, 2H) 7.23 (d, J = 8.0 Hz, 2H), 7.17−7.12 (m, 1H), 7.00 (d, J = 8.0 Hz, 2H), 6.10 (d, J = 4.5 Hz, 1H), 6.01 (d, J = 4.5 Hz, 1H), 5.97 (s, 1H), 5.69 (s, 1H), 2.21 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 160.2, 144.9, 141.0, 137.2, 136.3, 136.2, 132.0, 127.8, 127.7, 126.9, 125.6, 125.3, 123.1, 122.5, 118.9, 113.8, 109.1, 71.8, 19.8. Anal. Calcd for $C_{23}H_{20}N_4O_2$: C, 71.86; H, 5.24; N, 14.57. Found: C, 71.61; H, 5.27; N, 14.53.

Supporting Information Available: Crystallographic data for compounds **13**, **14-syn**, and **16**. This material is available free of charge via the Internet at http://pubs.acs.org.

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