HETEROCYCLIC COMPOUNDS FROM 3,4-DIAMINO-DIMETHYLAMINO-1-METHYLPYRAZOLO[3,4-*d*]PYRIMIDINE:

APPROACH TO NOVEL *ORTHO*- AND *PERI*-FUSED HETEROCYCLIC RING SYSTEM

Zhijun Wang and Richard Neidlein*

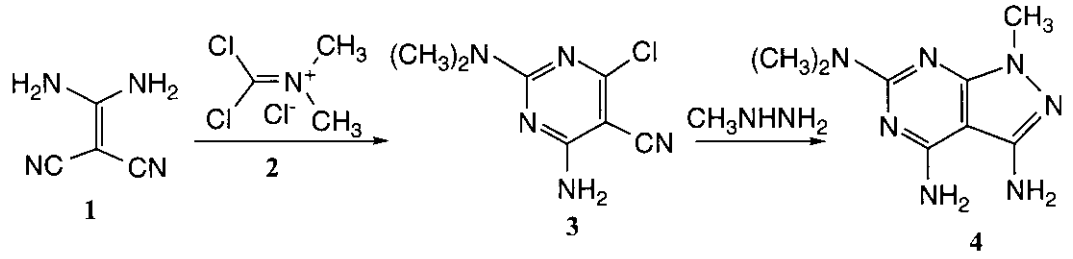
Pharmazeutisch-Chemisches Institut der Universität Heidelberg
Im Neuenheimer Feld 364, D-69120 Heidelberg, Germany

Abstract - Treatment of 3,4-diamino-6-dimethylamino-1-methylpyrazolo[3,4-*d*]pyrimidine (**4**) with acid chlorides (**5a-h**) led to formatiom of 3-substituted carbonylamino-4-amino-6-dimethylamino-1-methylpyrazolo[3,4-*d*]pyrimidines (**6a-h**), which reacted with *N,N*-dimethylformamide dimethyl acetal (**7**) to yield 4-dimethylaminoazomethinopyrazolo[3,4-*d*]pyrimidine derivatives (**8a-c**). Approach to novel *ortho*- and *peri*-fused tricyclic heterocyclic system, namely, 1,2,3,5,6,8-hexaazaacenaphthylene derivatives (**11, 12**) is also reported.

INTRODUCTION

Ketene acetals became known already in 1907, but the first dicyanoketene acetal was reported by W. J. Middleton *et al.* fifty years later as they systematically studied synthesis and reactions of tetracyanoethylene.[1] At the same time, they reported that when dicyanoketene ethylene acetal was treated with an excess of ammonia, both of the alkoxy groups were replaced and 1,1-diamino-2,2-dicyanoethylene (**1**) was formed; the first synthesis of dicyanoketene[2] and its chemical reactions were done 1980. The only reaction of **1** studied by W. J. Middleton *et al.* was its condensation reaction with ethyl malonate to give 2-dicyanomethylene-4,6-dioxo-hexahydropyrimidine.[1b] All dicyanoketene acetals were prepared from tetracyanoethylene by method of Middleton *et al.*[1] till 1988, when D. Kikelj in our group developed another convenient method to synthesize dicyanoketene ethylene acetal from sodium salt of malonodinitrile and 2-chlorethyl chloroformate in acetonitrile.[3] This prompted us to investigate the utilities of **1** in heterocyclic organic synthesis. Using **1** as starting material we have recently synthesized a variety of heterocyclic compounds covering pyrimidines,[4] pyrazolo[3,4-*d*]pyrimidines,[5] pyrimido[4,5-*d*]pyrimidines[6] and a novel *ortho*- and *peri*-fused tricyclic heterocyclic ring system in which a diazepine ring is *ortho*- and *peri*-fused to a pyrimido[4,5-*d*]pyrimidine skeleton.[6] As continuation of our investigation, we describe in the present paper preparation of a series of pyrazolo[3,4-*d*]pyrimidine derivatives (**6a-h, 8a-c, 9a-b, 10**) and approach to a novel *ortho*- and *peri*-fused tricyclic heterocyclic ring system, namely, 1,2,3,5,6,8-hexaazaacenaphthylene derivatives (**11, 12**) from 3,4-diamino-6-dimethylamino-1-methylpyrazolo[3,4-*d*]pyrimidine (**4**) which is easily available from 1,1-diamino-2,2-dicyanoethylene (**1**) (as shown in Scheme 1).

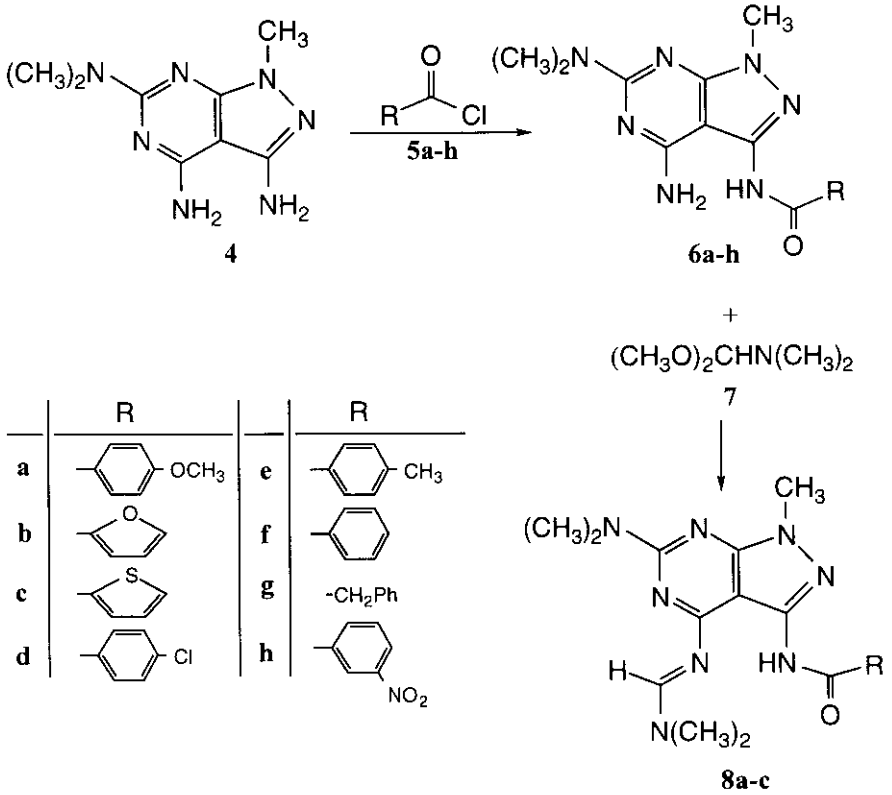
Scheme 1



RESULTS AND DISCUSSION

Treatment of 3,4-diamino-6-dimethylamino-1-methylpyrazolo[3,4-*d*]pyrimidine (**4**) with acid chlorides (**5a-h**) in acetonitrile (or chloroform) afforded 3-substituted carbonylaminopyrazolo[3,4-*d*]pyrimidine derivatives (**6a-h**) (as shown in Scheme 2). It was beyond our exceptation that only one of

Scheme 2



the amino groups in **4** reacted, even though acid chloride was excessive. The attempt to amidate the rest amino group in **6a** with acetyl chloride, acetic anhydride and trifluoroacetic anhydride was not successful. We could not obtain satisfactory crystals of **6** for X-Ray diffraction study to confirm their structures. But after comparing the ^{13}C-NMR spectra of **4** with **6a** (see Figure 1), it is not difficult to find that the

amino group at 3- position was amidated. Thus, besides the C-atom signals of anisoyl group [δ= 55.5 (-, OCH_3), 114.1 (-, C-3′), 125.4 (+, C-1′), 129.5 (-, C-2′), 163.1 (+, C-4′), 166.5 (+, C=O) ppm] the only obvious difference is that the signal for C-3 in **4** at δ= 147.2 (+) ppm[5] (Figure 1a) vanished and at the meanwhile a new signal at δ= 137.4 (+) ppm appeared (Figure 1b). That the amino group at 3- position is more reactive than the other one is in accordance with our previous observation.[5]

Because of its high reactivity, *N,N*-dimethylformamide dimethyl acetal (**7**) is widely used for heterocyclic synthesis.[7,8] **7** reacted with **6a-c** in toluene under reflux to yield 4-dimethylamino-azomethinopyrazolo[3,4-*d*]pyrimidine derivatives (**8a-c**) (see Scheme 2).When **4** was treated with one mole **7** in toluene at 90°C for 7 h, monoazomethino substituted pyrazolo[3,4-*d*]pyrimidine derivatives (**9a-b**) were formed in yields of 63.0% and 17.2% respectively (as shown in Scheme 3). This indicates also that the amino group at 3- position is more reactive as mentioned above. Treatment of an excess of **7** with **4** provided **10**.

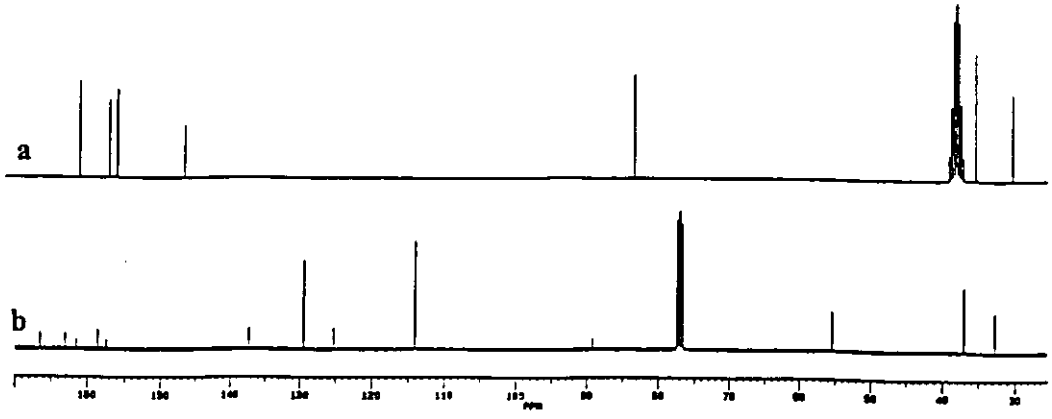
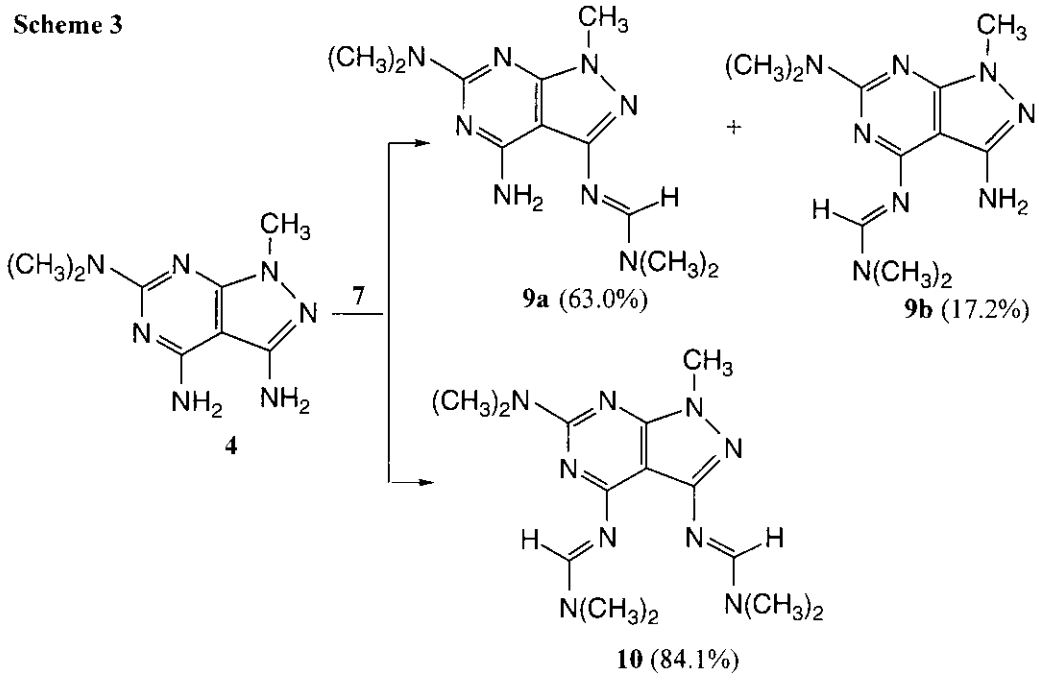


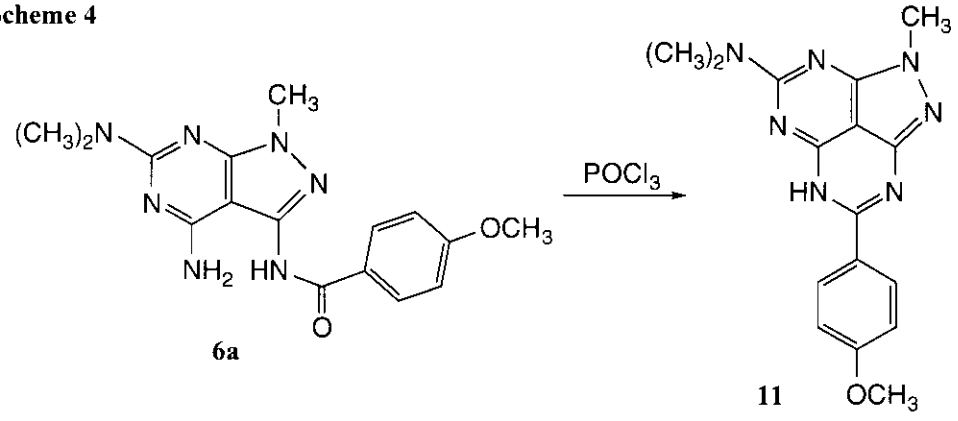
Figure 1: a) 62.89 MHz ^{13}C-NMR spectrum of **4** in DMSO-d_6
b) 62.89 MHz ^{13}C-NMR spectrum of **6a** in $CDCl_3$

Previously we attempted to synthesize *ortho*- and *peri*-fused tricyclic heterocyclic compounds from **4** and aldehydes, but no expected products were obtained.[5] Treatment of **9a**, **10** and **8a** in xylene under reflux led to no cyclization, even though dimethylamino-substituent in dimethylaminoazomethino group is a relative good leaving group. After treatment of **6a** with $POCl_3$ under reflux for 3.5 h, 1,5-dihydro-7-dimethylamino-5*H*-1-methyl-4-(4-methoxyphenyl)-1,2,3,5,6,8-hexaazaacenaphthylene (**11**) was isolated in yield of 6.2% (see Scheme 4). Its ^{1}H-NMR spectrum shows that the NH signals [at δ= 6.31 (s, 2H, NH_2), 8.97 (s, 1H, CONH) ppm] of **6a** disappeared and a new NH signal at δ= 5.54 (s, 1H) ppm emerged, which indicated the formation of cyclization. As shown in Scheme 5, **4** reacted with ethyl chloroformate in acetonitrile at room temperature to yield 7-dimethylamino-1-methyl-1,3,5-trihydro-1,2,3,5,6,8,-hexaazaacenaphthylen-4(3,5*H*)-one (**12**) (23.6%). The absorption of C=O (ν= 1719 cm^{-1}) in its IR spectrum and the NH signals [δ= 7.09 (s, 1H), 10.04 (s, 1H) ppm] in ^{1}H-NMR spectrum provided evidences for the structure of **12**.

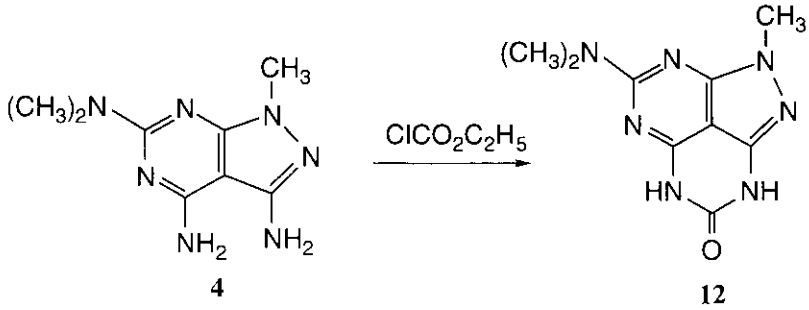
Scheme 3



Scheme 4



Scheme 5



In summary, using 3,4-diamino-6-dimethylamino-1-methylpyrazolo[3,4-*d*]pyrimidine (**4**) as educt a

variety of substituted pyrazolo[3,4-*d*]pyrimidine derivatives were prepared, a novel *ortho*- and *peri*-fused tricyclic heterocyclic ring system, namely, 1,2,3,5,6,8-hexaazaacenaphthylene was accessible.

EXPERIMENTAL

Melting points were determined on a Reichert hot stage microscope and are uncorrected. IR spectra were measured with a Perkin-Elmer spectrophotometer 283 using potassium bromide and are given as cm^{-1}. ^1H- and ^{13}C-NMR spectra were recorded on either a Bruker WM-250 (^1H-NMR: 250.13 MHz, ^{13}C-NMR: 62.89 MHz), Bruker WM-360 (^1H-NMR: 360MHz, ^{13}C-NMR: 90.56 MHz) or a Varian XL 300 (^1H-NMR: 299.95 MHz, ^{13}C-NMR: 75.43 MHz) spectrometer in DMSO-d_6 or $CDCl_3$. The chemical shifts are reported in parts per million (ppm) downfield from internal tetramethylsilane. Electron impact MS spetra were obtained on a Varian MAT 311A instrument. Element analyses were performed on a Heraeus Vario EL CHNS apparatus.

General procedure for the preparation of 6a-h:

A solution of **4** (0.31 g, 1.5 mmol), triethyl amine (0.3 mL, 2.25 mmol) and corresponding acid chloride (**5a-h**) (1.75 mmol) in water-free acetonitrile (60 mL) was stirred at rt for 24-125 h. After removal of the solvent under reduced pressure the residue was chromatographed on a silica column (70-230 mesh) using ethyl acetate/petroleum ether (3:1) as eluent to give **6a-h**.

4-Amino-6-dimethylamino-3-[(4-methoxybenzoyl)amino]-1-methylpyrazolo[3,4-*d*]pyrimidine (6a) (82.5%). mp 224-227°C (ethyl acetate). IR (KBr): 3314, 3140 (NH); 1665 (C=O); 1632, 1605, 1546 (C=C, C=N); 1395; 1257. ^1H-NMR (250.13 MHz, $CDCl_3$): δ= 3.13 (s, 6H, N(C**H**$_3$)$_2$); 3.70 (s, 3H, NC**H**$_3$); 3.86 (s, 3H, OC**H**$_3$); 6.31 (s, 2H, N**H**$_2$); 6.94 (dd, J= 6.9, 2.1 Hz, 2H, H-3′); 7.91 (dd, J= 6.9, 2.1 Hz, 2H, H-2′), 8.97 (s, 1H, CON**H**). ^{13}C-NMR (62.89 MHz, $CDCl_3$): δ= 32.7 (-, NCH_3); 37.1 (-, N(CH_3)$_2$); 55.5 (-, OCH_3); 89.2 (+, C-3a); 114.1 (-, C-3′); 125.4 (+, C-1′); 129.5 (-, C-2′); 137.4 (+, C-3); 157.5 (+, C-7a); 158.6 (+, C-4); 161.6 (+, C-6); 163.1 (+, C-4′); 166.5 (+, **C**ONH). MS m/z (%): $[M+1]^+$: 342 (16); M^+: 341 (75); 135 (100); 107 (12); 92 (12); 77 (25). Anal. Calcd for $C_{16}H_{19}N_7O_2$: C, 56.30; H, 5.61; N, 28.72. Found: C, 56.45; H, 5.76; N, 28.47.

4-Amino-6-dimethylamino-3-[(furan-2-carbonyl)amino]-1-methylpyrazolo[3,4-*d*]pyrimidine (6b) (60.2%). mp 171°C (ethyl acetate). IR (KBr): 3457, 3366, 3172 (NH); 1689 (C=O); 1662, 1640, 1588, 1569 (C=C, C=N); 1397; 1269; 864; 753. ^1H-NMR (250.13 MHz, $CDCl_3$): δ= 3.14 (s, 6H, N(C**H**$_3$)$_2$); 3.77 (s, 3H, NC**H**$_3$); 6.34 (s, 2H, N**H**$_2$); 6.57 (dd, J= 3.5, 1.9 Hz, 1H, H-4′); 7.28 (t, J= 4.2 Hz, 1H, H-3′); 7.54 (t, J= 1.1 Hz, 1H, H-5′); 8.80 (s, 1H, CON**H**). ^{13}C-NMR (90.56 MHz, $CDCl_3$): δ= 32.8 (-, N**C**H_3); 37.0 (-, N(**C**H_3)$_2$); 88.9 (+, C-3a); 112.8 (-, C-4′); 116.6 (-, C-3′); 136.0(+, C-3); 145.3 (-, C-5′); 146.8 (+, C-2′); 157.1 (+, C-7a); 157.4 (+, C-4); 158.4 (+, C-6); 161.5 (+, **C**ONH). MS m/z (%): $[M+1]^+$: 302 (15); M^+: 301 (100); 286 (22); 272 (20); 95 (58); 71 (10); 44 (8). Anal. Calcd for $C_{13}H_{15}N_7O_2$: C, 51.82; H, 5.02; N, 32.54. Found: C, 51.48; H, 5.18; N, 32.05. HRMS: Calcd for $C_{13}H_{15}N_7O_2$: 301.1286. Found: 301.1285.

4-Amino-6-dimethylamino-1-methyl-3-[(thiophene-2-carbonyl)amino]pyrazolo[3,4-*d*]pyrimidine (6c) (61.5%). mp 229°C (ethyl acetate). IR (KBr): 3440, 3329, 3249 (NH); 1671 (C=O); 1641, 1611, 1553 (C=C, C=N); 1393; 1266; 785; 715. ^{1}H-NMR (250.13 MHz, $CDCl_3$): δ= 3.12 (s, 6H, N(C**H**$_3$)$_2$); 3.69 (s, 3H, NC**H**$_3$); 6.72 (s, 2H, N**H**$_2$); 7.23 (t, J= 4.8 Hz, 1H, H-4′); 7.90 (d, J= 4.5 Hz, 1H, H-5′); 8.12 (d, J= 3.3 Hz, 1H, H-3′); 10.85 (s, 1H, CON**H**). ^{13}C-NMR (90.56 MHz, $CDCl_3$): δ= 32.4 (-, N**C**H$_3$); 36.6 (-, N(**C**H$_3$)$_2$); 89.7 (+, C-3a); 128.3 (-, C-4′); 130.3 (-, C-5′); 132.6 (-, C-3′); 136.6 (+, C-3); 138.4 (+, C-2′); 156.5 (+, C-7a); 157.8 (+, C-4); 161.1 (+, C-6); 161.5 (+, **C**ONH). MS m/z (%): $[M+1]^+$: 318 (13); M^+: 317 (82); 302 (16); 288 (17); 111 (100); 71 (9); 44 (6). HRMS: Calcd for $C_{13}H_{15}N_7OS$: 317.1058. Found: 317.1057.

4-Amino-3-[(4-chlorobenzoyl)amino]-6-dimethylamino-1-methylpyrazolo[3,4-*d*]pyrimidine (6d) (60.9%). mp 228°C (ethyl acetate). IR (KBr): 3415, 3293, 3219 (NH); 1657 (C=O); 1636, 1600, 1570, 1545 (C=C, C=N); 1393; 1088; 903; 850; 788. ^{1}H-NMR (250.13 MHz, DMSO-d_6): δ= 3.12 (s, 6H, N(C**H**$_3$)$_2$); 3.70 (s, 3H, NC**H**$_3$); 6.68 (s, 2H, N**H**$_2$); 7.60 (d, J= 8.6 Hz, 2H, H-3′); 8.06 (d, J= 8.6 Hz, 2H, H-2′); 10.79 (s, 1H, CON**H**). ^{13}C-NMR (62.89 MHz, DMSO-d_6): δ= 32.5 (-, N**C**H$_3$); 36.7 (-, N(**C**H$_3$)$_2$); 89.9 (+, C-3a); 128.4 (-, C-3′); 129.9 (-, C-2′); 132.1 (+, C-1′); 136.9, 137.0 (2+, C-3, C-4′); 156.5 (+, C-7a); 157.7 (+, C-4); 161.2 (+, C-6); 165.9 (+, **C**ONH). MS m/z (%): $[M+2]^+$: 347 (18); M^+: 345 (62); 330 (12); 316 (16); 141 (31); 139 (100); 111 (25); 71 (10); 44 (6). Anal. Calcd for $C_{15}H_{16}N_7OCl$: C, 52.10; H, 4.66; N, 28.35. Found: C, 52.30; H, 4.89; N, 27.99. HRMS: Calcd for $C_{15}H_{16}N_7OCl$: 345.1105. Found: 345.1107.

4-Amino-6-dimethylamino-1-methyl-3-[(*p*-methylbenzoyl)amino]pyrazolo[3,4-*d*]pyrimidine (6e) (64.6%). mp 102-105°C (ethyl acetate). IR (KBr): 3415, 3300, 3239 (NH); 1671 (C=O); 1648, 1609, 1575, 1549 (C=C, C=N); 1395; 1284; 1266; 903; 786. ^{1}H-NMR (250.13 MHz, $CDCl_3$): δ= 2.42 (s, 3H, C**H**$_3$); 3.13 (s, 6H, N(C**H**$_3$)$_2$); 3.72 (s, 3H, NC**H**$_3$); 7.27 (d, J= 8.0 Hz, 2H, H-3′); 7.83 (d, J= 8.2 Hz, 2H, H-2′); 8.83 (s, 1H, CON**H**). ^{13}C-NMR (90.56 MHz, $CDCl_3$): δ= 21.6 (-, **C**H$_3$); 32.7 (-, N**C**H$_3$); 37.0 (-, N(**C**H$_3$)$_2$); 89.1 (+, C-3a); 127.5 (-, C-2′); 129.5 (-, C-3′), 130.1 (+, C-1′), 137.1 (+, C-3); 143.3 (+, C-4′); 157.4 (+, C-7a); 158.5 (+, C-4); 161.5 (+, C-6); 166.9 (+, **C**ONH). MS m/z (%): $[M+1]^+$: 326 (13); M^+: 325 (60); 296 (8); 119 (100); 91 (33). Anal. Calcd for $C_{16}H_{19}N_7O$: C, 59.06; H, 5.89; N, 30.13. Found: C, 58.80; H, 6.19; N, 29.97. HRMS: Calcd for $C_{16}H_{19}N_7O$: 325.1649. Found: 325.1647.

4-Amino-3-benzylcarbonylamino-6-dimethylamino-1-methylpyrazolo[3,4-*d*]pyrimidine (6f) (59.1%). mp 188-189°C (ethyl acetate). IR (KBr): 3426, 3308, 3217 (NH); 1653 (C=O); 1600, 1576, 1542 (C=C, C=N); 1393; 787; 738; 702. ^{1}H-NMR (250.13 MHz, $CDCl_3$): δ= 3.16 (s, 6H, N(C**H**$_3$)$_2$); 3.68 (s, 3H, NC**H**$_3$); 3.76 (s, 2H, C**H**$_2$Ph); 6.17 (s, 2H, N**H**$_2$); 7.26-7.37 (m, 5H, $H_{arom.}$); 8.23 (s, 1H, CON**H**). ^{13}C-NMR (62.89 MHz, $CDCl_3$): δ= 32.6 (-, N**C**H$_3$); 36.9 (-, N(**C**H$_3$)$_2$); 43.9 (+, **C**H$_2$Ph); 88.9 (+, C-3a); 127.8 (-, C-4′); 129.2 (-, C-3′), 129.4 (-, C-2′); 133.6 (+, C-1′), 136.6 (+, C-3); 157.3 (+, C-7a); 158.3 (+, C-4); 161.5 (+, C-6); 171.0 (+, **C**ONH). MS m/z (%): $[M+1]^+$: 326 (24); M^+: 325 (100); 234 (48); 207 (89); 192 (29); 178 (24); 164 (22); 91 (41); 71 (13); 44 (10). Anal. Calcd for $C_{16}H_{19}N_7O$:

C, 59.06; H, 5.89; N, 30.13. Found: C, 59.29; H, 6.07; N, 29.81. HRMS: Calcd for $C_{16}H_{19}N_7O$: 325.1649. Found: 325.1647.

4-Amino-3-benzoylamino-6-dimethylamino-1-methylpyrazolo[3,4-*d*]pyrimidine (6g) (85.7%). mp 138°C (ethyl acetate). IR (KBr): 3320, 3165 (NH); 1670 (C=O); 1627, 1600, 1580, 1549 (C=C, C=N); 1393; 1342; 791; 706. ^{1}H-NMR (250.13 MHz, $CDCl_3$): δ= 3.20 (s, 6H, N(C**H**$_3$)$_2$); 3.71 (s, 3H, NC**H**$_3$); 6.29 (s, 2H, N**H**$_2$); 7.46-7.59 (m, 3H, H-3′, 4′); 7.95 (d, J= 8.5 Hz, 2H, H-2′); 8.89 (s, 1H, CON**H**). ^{13}C-NMR (62.89 MHz, $CDCl_3$): δ= 32.7 (-, N**C**H$_3$); 37.1 (-, N(**C**H$_3$)$_2$); 89.1 (+, C-3a); 127.6 (-, C-2′); 128.8 (-, C-3′), 129.4 (-, C-2′); 132.6 (-, C-4′), 133.3 (+, C-1′); 137.0 (+, C-3); 157.5 (+, C-7a); 158.5 (+, C-4); 161.6 (+, C-6); 166.9 (+, **C**ONH). MS m/z (%): $[M+1]^+$: 312 (21); M^+: 311 (96); 296 (17); 282 (21); 105 (100); 77 (65); 71 (10); 44 (7). HRMS: Calcd for $C_{15}H_{17}N_7O$: 311.1495. Found: 311.1495.

4-Amino-6-dimethylamino-1-methyl-3-[(3-nitrobenzoyl)amino]pyrazolo[3,4-*d*]pyrimidine (6h) (35.6%). mp 255°C (ethyl acetate). IR (KBr): 3437, 3247 (NH); 1670 (C=O); 1602, 1570, 1529 (C=C, C=N); 1395; 1263; 789; 716. ^{1}H-NMR (250.13 MHz, DMSO-d_6): δ= 3.13 (s, 6H, N(C**H**$_3$)$_2$); 3.70 (s, 3H, NC**H**$_3$); 6.73 (s, 2H, N**H**$_2$); 7.83 (t, J= 8.1 Hz, H-5′); 8.45 (q, J= 8.0 Hz, 2H, H-4′, 6′); 8.86 (s, 1H, H-2′); 11.01 (s, 1H, CON**H**). ^{13}C-NMR (90.56 MHz, DMSO-d_6): δ= 32.5 (-, N**C**H$_3$); 36.6 (-, N(**C**H$_3$)$_2$); 89.8 (+, C-3a); 122.9 (-, C-2′); 126.3 (-, C-4′), 130.1 (-, C-5′); 134.3 (-, C-6′), 135.0 (+, C-1′); 136.7 (+, C-3); 147.6 (+, C-3′); 156.5 (+, C-7a); 157.5 (+, C-4); 161.2 (+, C-6); 164.8 (+, **C**ONH). MS m/z (%): $[M+1]^+$: 357 (20); M^+: 356 (100); 341 (24); 327 (26); 234 (10); 150 (33); 104 (25); 76 (22); 71 (15); 44 (11). HRMS: Calcd for $C_{15}H_{16}N_8O_3$: 356.1346. Found: 356.1347.

General procedure for the preparation of 8a-c:

A solution of *N,N*-dimethylformamide dimethyl acetal (**7**) 1.2 g (10 mmol) and corresponding substituted 4-aminopyrazolo[3,4-*d*]pyrimidine (**6a-c**) (0.5 mmol) in absolute toluene (10 mL) was refluxed for 6 h. After removal of the solvent the residue was chromatographed on a silica column (70-230 mesh) using acetone/ethyl acetate (1:1) as eluent to give **8a-c**.

6-Dimethylamino-4-dimethylaminoazomethino-3-[(4-methoxybenzoyl)amino]-1-methylpyrazolo[3,4-*d*]pyrimidine (8a) (80.8 %). mp 210°C (acetone). IR (KBr): 3347 (NH); 1671 (C=O); 1642, 1602, 1570, 1542 (C=C, C=N); 1398; 1253. ^{1}H-NMR (360 MHz, DMSO-d_6): δ= 2.85, 3.12 (2s, 6H, N(C**H**$_3$)$_{2azometh.}$); 3.17 (s, 6H, N(C**H**$_3$)$_2$); 3.71 (s, 3H, NC**H**$_3$); 3.83 (s, 3H, OC**H**$_3$); 7.04 (d, J= 8.9 Hz, 2H, H-3′); 7.93 (d, J= 8.9 Hz, 2H, H-2′); 8.76 (s, 1H, NC**H**N); 9.88 (s, 1H, CON**H**). ^{13}C-NMR (90.56 MHz, DMSO-d_6): δ= 32.4 (-, N**C**H$_3$); 34.4, 40.6 (2-, N(**C**H$_3$)$_{2azometh.}$); 36.8 (-, N(**C**H$_3$)$_2$); 55.5 (-, O**C**H$_3$); 94.5 (+, C-3a); 113.6 (-, C-3′); 126.3 (+, C-1′); 129.2 (-, C-2′); 139.4 (+, C-3); 156.4 (+, C-7a); 156.7 (-, N**C**HN); 161.3, 161.7 (2+, C-4, 6); 161.9 (+, C-4′); 163.8 (+, **C**ONH). MS m/z (%): $[M+1]^+$: 397 (17); M^+: 396 (73); 381 (10); 353 (9); 135 (100); 77 (9); 44 (7); 42 (9). HRMS: Calcd for $C_{19}H_{24}N_8O_2$: 396.2021. Found: 396.2020.

6-Dimethylamino-4-dimethylaminoazomethino-3-[(furan-2-carbonyl)amino]-1-

methylpyrazolo[3,4-*d*]pyrimidine (8b) (51.7 %). mp 221-223°C (chloroform). IR (KBr): 3537, 3434, 3307 (NH); 1675 (C=O); 1643, 1611, 1570, 1544 (C=C, C=N); 1328; 1095. ^{1}H-NMR (360 MHz, $CDCl_3$): δ= 3.21 (s, 9H, N(CH_3)$_2$, NC$H_{3azometh.}$); 3.28 (s, 3H, NC$H_{3azometh}$); 3.82 (s, 3H, NCH_3); 6.53 (t, J= 3.6 Hz, 1H, H-4′); 7.27 (t, J= 4.0 Hz, 1H, H-3′); 7.33 (t, J= 1.0 Hz, 1H, H-5′); 8.86 (s, 1H, NC**H**N); 10.07 (s, 1H, CON**H**). ^{13}C-NMR (90.56 MHz, $CDCl_3$): δ= 32.9 (-, NCH_3); 34.8, 41.5 (2-, N(CH_3)$_{2azometh.}$); 37.2 (-, N(CH_3)$_2$); 92.8 (+, C-3a); 112.7 (-, C-4′); 115.3 (-, C-3′); 140.3 (+, C-3); 143.5 (-, C-5′); 148.2 (+, C-2′); 153.8 (+, C-7a); 156.1 (+, C-4); 156.6 (-, N**C**HN); 161.6 (+, C-6); 162.2 (+, C-4′); 163.8 (+, **C**ONH). MS m/z (%): [M+1]$^+$: 357 (24); M$^+$: 356 (100); 341 (28); 312 (14); 232 (10); 95 (58); 57 (10); 44 (20); 42 (23). HRMS: Calcd for $C_{16}H_{20}N_8O_2$: 356.1710. Found: 356.1711.

6-Dimethylamino-4-dimethylaminoazomethino-1-methyl-3-[(thiophene-2-carbonyl)amino]pyrazolo[3,4-*d*]pyrimidine (8c) (65.6%). mp 214°C (chloroform). IR (KBr): 3320 (NH); 1666 (C=O); 1636, 1603, 1570, 1534 (C=C, C=N); 1421; 1399; 797; 736. ^{1}H-NMR (360 MHz, $CDCl_3$): δ= 3.20, 3.21 (2s, 12H, N(CH_3)$_2$, N(CH_3)$_{2azometh.}$); 3.85 (s, 3H, NCH_3); 7.07 (dd, J= 5.0, 3.7 Hz, 1H, H-4′); 7.49 (dd, J= 5.0, 1.3 Hz, 1H, H-5′); 7.67 (dd, J= 3.7, 1.1 Hz, 1H, H-3′); 8.86 (s, 1H, NC**H**N); 9.52 (s, 1H, CON**H**). ^{13}C-NMR (90.56 MHz, $CDCl_3$): δ= 33.0 (-, NCH_3); 35.4, 41.6 (2-, N(CH_3)$_{2azometh.}$); 37.3 (-, N(CH_3)$_2$); 92.7 (+, C-3a); 127.5 (-, C-4′); 128.8 (-, C-5′); 130.4 (-, C-3′); 139.1 (+, C-3); 140.4 (+, C-2′); 156.2 (+, C-7a); 157.1 (-, N**C**HN); 157.7 (+, C-4); 161.7 (+, C-6); 162.1 (+, **C**ONH). MS m/z (%): [M+1]$^+$: 373 (22); M$^+$: 372 (100); 357 (29); 343 (15); 329 (9); 111 (54); 46 (8). HRMS: Calcd for $C_{16}H_{20}N_8OS$: 372.1480. Found: 372.1439.

4-Amino-6-dimethylamino-3-dimethylaminoazomethino-1-methylpyrazolo[3,4-*d*]pyrimidine (9a) and **3-Amino-6-dimethylamino-4-dimethylaminoazomethino-1-methylpyrazolo[3,4-*d*]pyrimidine (9b):**

A solution of **4** (0.41 g, 2 mmol) and *N,N*-dimethylformamide dimethyl acetal (**7**) (0.24 g, 2 mmol) in absolute toluene (20 mL) was stirred at 90°C for 7 h. After removal of the solvent the residue was chromatographed on a silica column (70-230 mesh) using ethyl acetate/acetone (1:1) as eluent. Two fractions (Rf= 0.31 (**9a**), Rf= 0.26 (**9b**)) were obtained as **9a** and **9b** respectively.

9a: - 0.33 g (63.0%). mp 193°C (chloroform). IR (KBr): 3425, 3312, 3188 (NH); 1630, 1593, 1545 (C=C, C=N); 1427; 1386; 1331; 1105; 982; 796. ^{1}H-NMR (250.13 MHz, $CDCl_3$): δ= 3.04 (s, 6H, N(CH_3)$_{2azometh.}$); 3.17 (s, 6H, N(CH_3)$_2$); 3.72 (s, 3H, NCH_3); 5.59 (s, 2H, NH_2); 8.25 (s, 1H, NC**H**N). ^{13}C-NMR (62.89 MHz, $CDCl_3$): δ= 32.4 (-, N**C**H$_3$); 37.2 (-, N(**C**H$_3$)$_2$); 34.3, 40.4 (2-, N(CH_3)$_{2azometh.}$); 89.0 (+, C-3a); 151.7 (+, C-3); 153.9 (-, N**C**HN); 157.1 (+, C-7a); 158.7 (+, C-4); 162.5 (+, C-6). MS m/z (%): [M+1]$^+$: 263 (20); M$^+$: 262 (100); 247 (31); 233 (12); 218 (13); 131 (10); 46 (27); 44 (12). Anal. Calcd for $C_{11}H_{18}N_8$: C, 50.37; H, 6.92; N, 42.72. Found: C, 50.54; H, 6.95; N, 42.66.

9b: -90 mg (17.2%). mp 198°C (chloroform). IR (KBr): 3433, 3280, 3185 (NH); 1636, 1595, 1557 (C=C, C=N); 1419; 1386; 1328; 1286; 1099; 801. ^{1}H-NMR (250.13 MHz, $CDCl_3$): δ= 3.11, 3.13 (2s, 6H,

$N(CH_3)_{2azometh.}$); 3.20 (s, 6H, $N(CH_3)_2$); 3.65 (s, 3H, NCH_3); 4.54 (s, 2H, NH_2); 8.79 (s, 1H, NCHN). ^{13}C-NMR (62.89 MHz, $CDCl_3$): δ= 32.2 (-, NCH_3); 37.2 (-, $N(CH_3)_2$); 37.8, 41.1 (2-, $N(CH_3)_{2azometh.}$); 92.0 (+, C-3a); 148.6 (+, C-3); 156.6 (-, NCHN); 157.3 (+, C-7a); 162.4 (+, C-6, C-4). MS m/z (%): $[M+1]^+$: 263 (15); M^+: 262 (100); 247 (36); 233 (13); 218 (19); 175 (12); 131 (7); 46 (13); 44 (11); 42 (14). Anal. Calcd for $C_{11}H_{18}N_8$: C, 50.37; H, 6.92; N, 42.72. Found: C, 50.39; H, 7.20; N, 42.56. HRMS: Calcd for $C_{11}H_{18}N_8$: 262.1654. Found: 262.1654.

6-Dimethylamino-3,4-bis[(dimethylamino)azomethino]-1-methylpyrazolo[3,4-*d*]pyrimidine (10): A solution of **4** (0.21 g, 1 mmol) and *N,N*-dimethylformamide dimethyl acetal (**7**) (0.60 g, 5 mmol) in absolute toluene (8 mL) was refluxed for 15 h. Then the mixture was cooled to -20°C overnight, the light yellow crystals were filtered and washed with ether to give 0.27 g **10** (84.1%). mp 194-197°C (chloroform). IR (KBr): 1640, 1619, 1582, 1534 (C=C, C=N); 1484; 1379; 1224; 1102; 1033; 970; 800. ^{1}H-NMR (360 MHz, $CDCl_3$): δ= 3.02, 3.07 (2s, 6H, $N(CH_3)_{2azometh.}$); 3.13, 3.16 (2s, 6H, $N(CH_3)_{2azometh.}$); 3.23 (s, 6H, $N(CH_3)_2$); 8.33 (s, 1H, NCHN); 8.63 (s, 1H, NCHN). ^{13}C-NMR (90.56 MHz, $CDCl_3$): δ= 32.5 (-, NCH_3); 34.2, 40.2 (2-, $N(CH_3)_{2azometh.}$); 34.9, 40.4 (2-, $N(CH_3)_{2azometh.}$); 37.3 (-, $N(CH_3)_2$); 94.2 (+, C-3a); 152.3 (+, C-3); 156.3 (-, NCHN); 157.7 (-, NCHN); 157.9 (+, C-7a); 161.6 (+, C-4); 163.5 (+, C-6). MS m/z (%): $[M+1]^+$: 318 (23); M^+: 317 (100); 302 (45); 288 (15); 273 (19); 246 (11); 230 (12); 159 (11); 46 (69); 44 (31); 42 (25). Anal. Calcd for $C_{14}H_{23}N_9$: C, 52.98; H, 7.30; N, 39.72. Found: C, 53.18; H, 7.42; N, 39.59.

1,5-Dihydro-7-dimethylamino-5*H*-1-methyl-4-(4-methoxyphenyl)-1,2,3,5,6,8-hexaazaacenaphthylene (11): A solution of **8a** (0.17 g, 0.5 mmol) in $POCl_3$ (4 mL, 43 mmol) was refluxed for 3.5 h. After removal of $POCl_3$ under reduced pressure, about 10 g of ice was added. The mixture was neutralized with sodium hydrogen carbonate to pH= 7. The precipitates were filtered and chromatographed on a silica column (70-230 mesh) using ethyl acetate as eluent to give 10 mg of **11** (6.2%). mp 140°C (chloroform). IR (KBr): 3372, 3211 (NH); 1729; 1647, 1608, 1545, 1513 (C=C, C=N); 1394; 1309; 1255; 1178; 801; 740. ^{1}H-NMR (360 MHz, $CDCl_3$): δ= 3.17 (s, 6H, $N(CH_3)_2$); 3.84, 3.87 (2s, 6H, NCH_3, OCH_3); 5.54 (s, 1H, NH); 6.96 (d, J= 8.9 Hz, 2H, H-3′); 7.89 (d, J= 8.9 Hz, 2H, H-2′). ^{13}C-NMR (90.56 MHz, $CDCl_3$): δ= 33.6 (-, NCH_3); 37.9 (-, $N(CH_3)_2$); 55.4 (-, OCH_3); 96.5 (+, C-8b); 114.3 (-, C-3′); 126.4 (+, C-1′); 128.8 (-, C-2′); 152.1 (+, C-2a); 154.5 (+, C-4); 155.2 (+, C-8a); 155.5 (+, C-5a); 162.3 (+, C-7); 165.5 (+, C-4′). MS m/z (%): $[M+1]^+$: 324 (21); M^+: 323 (100); 308 (25); 294 (19); 279 (14); 161 (8); 134 (17); 106 (7); 77 (5); 44 (7); 43 (8). HRMS: Calcd for $C_{16}H_{17}N_7O$: 323.1493. Found: 323.1491.

7-Dimethylamino-1-methyl-1,3,5-trihydro-1,2,3,5,6,8-hexaazaacenaphthylen-4(3,5*H*)-one (12): A solution of ethyl chloroformate (0.16 g, 1.5 mmol) in water-free acetonitrile (20 mL) was dropped at rt within 30 min to the mixture of **4** (0.21 g, 1 mmol), triethyl amine (0.3 mL, 2.25 mmol) and water-free acetonitrile (50 mL). The mixture was stirred for a week and then the solvent was removed under reduced pressure. The residue was chromatographed on a silica column (70-230 mesh) using ethyl acetate/acetone

(1:1) as eluent to give 55 mg **12** (23.6%). mp > 230°C (acetone). IR (KBr): 3348, 3240 (NH); 1719 (C=O); 1634, 1596, 1546 (C=C, C=N); 1395; 1310; 788. ^{1}H-NMR (360 MHz, DMSO-d_6): δ= 3.12 (s, 6H, N(C**H**$_3$)$_2$); 3.66 (s, 3H, NC**H**$_3$); 7.09 (s, 1H, CON**H**); 10.04 (s, 1H, CON**H**). ^{13}C-NMR (90.56 MHz, DMSO-d_6): δ= 32.4 (-, N**C**H$_3$); 36.7 (-, N(**C**H$_3$)$_2$); 87.2 (+, C-8b); 138.2 (+, C-2a); 154.0 (+, C-5a); 156.4 (+, C-8a); 157.5 (+, C-7); 161.3 (+, **C**=O). MS m/z (%): [M+1]$^+$: 234 (11); M$^+$: 233 (83); 218 (42); 207 (100); 204 (34); 192 (39); 178 (22); 164 (29); 147 (19); 71 (32); 57 (11); 44 (34); 43 (34); 42 (26). HRMS: Calcd for $C_9H_{11}N_7O$: 233.1026. Found: 233.1027.

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