Hypervalent Iodine in Synthesis

Part 86

Selective Copper-Catalyzed *N*-Monoarylation and N^1,N^3-Diarylation of Uracil and Its Derivatives with Diaryliodonium Salts

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N-Arylation of uracil and its derivatives **2** with diaryliodonium salts **1** was investigated in order to explore a new synthetic methodology associated with *N*-aryluracil derivatives. In the presence of K_2CO_3, the copper-catalyzed arylation gave N^1,N^3-diarylation products with high selectivity and in good yields (*Table 2*). However, the use of NaOAc as the base in the copper-catalyzed arylation of 6-methyluracil (**2a**) resulted in N^3-arylation products with high selectivity, and, in the copper-catalyzed arylation of uracil (**2b**) or 5-methyluracil (= thymine; **2c**), N^1-arylation products were the major products (*Table 3*).

Introduction. – Many *N*-substituted uracil derivatives possess biological activity [1]. They are also useful as biochemical diagnostic probes [2] and as potential synthons [3]. Several methods for the synthesis of these compounds are known, *e.g.*, N^1,N^3-diaryluracils have been prepared by base-catalyzed condensation of enamines with aryl isocyanates [4]; N^1,N^3-diaryl-methyluracils have been obtained by treating 1,3-diaryl-ureas with diketene [5]; N^1-aryluracils have been synthesized from substituted ureidopropanoic acids or 1-acrylyl-3-arylureas [6]; N^1-aryl-6-methyluracils have been obtained from the reaction of 6-methyl-1,3-oxazine-2,4(3*H*)-dione with arylamines [7]; N^3-aryluracils have been synthesized *via* cycloreversion of norbornene-fused pyrimidinediones [8]; N^3-aryl-6-methyluracils have been prepared by the cyclization of ureidobutenoate [9]. However, methods involving the direct *N*-arylation of uracil have rarely been reported [10].

As part of our research interest in the synthetic applications of transition-metal-catalyzed arylation reactions with diaryliodonium salts [11], the copper-catalyzed arylation of uracil and its derivatives with diaryliodonium salts was investigated to achieve N^1,N^3-diarylation or *N*-monoarylation with high selectivity.

Results and Discussion. – To find the optimum arylation conditions, the effects of bases and solvents on *N*-phenylation of 6-methyluracil (**2a**) with diphenyliodonium tetrafluoroborate (**1a**) were examined, which yielded 6-methyl-1,3-diphenyluracil (**3a**) and 6-methyl-3-phenyluracil (**4a**) (see *Table 1*). The results showed that DMF was the

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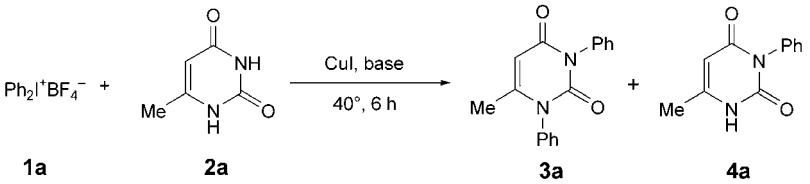
Table 1. *Effect of Base and Solvent on* N-*Phenylation of 6-Methyluracil* (**2a**). Conditions: all reactions were run with diphenyliodonium tetrafluoroborate (**1a**; 1 mmol), **2a** (1 mmol), CuI (10 mol-%), base (2 mmol), and solvent (5 ml) under N_2 at 40° for 6 h.



1a **2a** **3a** **4a**

Base	Solvent	Yield[a]) of **3a** [%]	Yield[a]) of **4a** [%]
K_2CO_3	DMF	59	5
Na_2CO_3	DMF	30	21
$NaHCO_3$	DMF	8	37
K_3PO_4	DMF	trace	40
NaOAc	DMF	trace	59
K_2HPO_4	DMF	–	trace
K_2CO_3	DMF/H_2O 4.5 : 0.5	5	32
K_2CO_3	DMF/H_2O 4.75 : 0.25	7	50
K_2CO_3	$CHCl_3$	7	12
K_2CO_3	CH_2Cl_2	29	4

[a]) Isolated yield based on **1a**

best choice of solvent, K_2CO_3 the most-suitable base for N^1,N^3-diarylation, and NaOAc the most-suitable base for N^3-arylation.

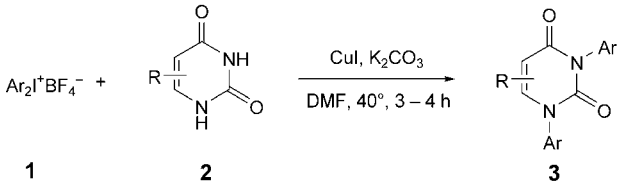
To establish the universality of the reaction, first the N^1,N^3-diarylation of uracil (**2b**) was investigated. In the presence of K_2CO_3 and CuI, the reaction of diaryliodonium salts **1** with uracil was complete after 3–4 h at 40° in DMF, to give N^1,N^3-diarylation products **3** in good yield and high selectivity (see *Table 2*). The reaction of diaryliodonium salts **1** with uracil derivatives such as 6-methyluracil (**2a**) or thymine (**2c**) under the same reaction conditions was straightforward, as predictable products were obtained (see *Table 2*).

The reaction of 6-methyluracil (**2a**) with diaryliodonium salts **1** for 10 h at 40° in DMF was examined in the presence of NaOAc as the base instead of K_2CO_3. N^3-Arylation products were formed with high selectivity, besides a small amount of N^1,N^3-diarylation products; but no N^1-arylation took place (see *Table 3*, *Entries 1–5*). The reactions of uracil (**2b**) and thymine (**2c**) with diaryliodonium salts **1** in the presence of NaOAc yielded N^1-arylation products as the major product (*Entries 6–13*), besides a small amount of N^1,N^3-diarylation product and, in some cases, the N^3-arylation product (*Entries 12* and *13*).

Although the different results of the *N*-arylation of 6-methyluracil (**2a**) compared with that of both uracil (**2b**) and thymine (**2c**) in the presence of a weak base such as NaOAc can be explained by steric hindrance at the N^1-position of **2a** due to Me–C(6), the regioselectivity of *N*-arylation is also influenced by the fact that H–N(1) of both **2b** and **2c** being more acidic than H–N(3).

The position of monoarylation of **2** was determined by the *Shugar–Fox* method [12], which is based on the induced bathochromic shift in the UV spectrum of the

Table 2. N^1,N^3-*Diarylation of Uracil* (**2b**), *6-Methyluracil* (**2a**), *or Thymine* (**2c**). Conditions: all reactions were run with **1** (1.2 mmol), **2** (0.5 mmol), CuI (10 mol-%), K_2CO_3 (2 mmol), and DMF (5 ml) under N_2 at 40° for 3–4 h.



1 **2** **3**

Ar	R	Product	Yield[a]) [%]
Ph	6-Me	**3a**	83
4-MeC_6H_4	6-Me	**3b**	65
4-ClC_6H_4	6-Me	**3c**	69
4-BrC_6H_4	6-Me	**3d**	55
Ph	H	**3e**	68
4-MeC_6H_4	H	**3f**	62
4-ClC_6H_4	H	**3g**	72
Ph	5-Me	**3h**	72
4-MeC_6H_4	5-Me	**3i**	85
4-BrC_6H_4	5-Me	**3j**	52

[a]) Isolated yield based on uracil.

product on changing from neutral to alkaline pH. This shift is 20–30 nm in the case of the 3-substituted product of uracil and its derivatives and is missing in the case of the 1-substituted product of uracil and its derivatives. The position of monoarylation of **2** can also be determined by MS analysis of the 1- or 3-substituted products of uracil [13]. For example, the fragmentions of N^1-(4-methylphenyl)thymine (**5g**) were different from those of N^3-(4-methylphenyl)thymine (**5g′**) (see *Scheme*).

Conclusions. – The copper-catalyzed *N*-arylation of uracil or its derivatives with diaryliodonium salts proceeds under mild reaction conditions. With the aid of a suitable base, a convenient method for the synthesis of N^1,N^3-diaryluracil, N^3-aryl-6-methyluracil, N^1-aryluracil, and N^1-arylthymine has been developed.

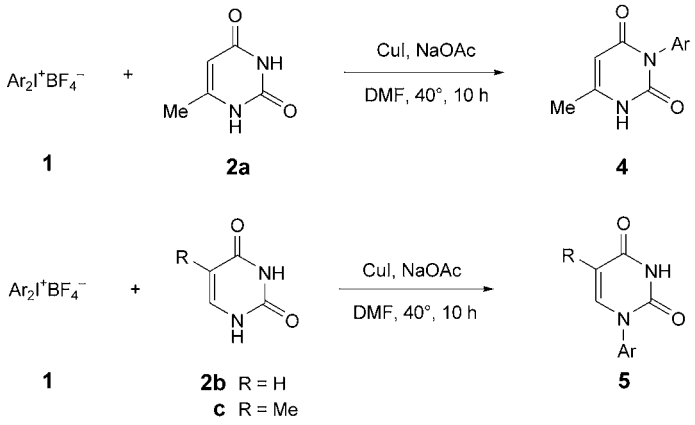
Experimental Part

General. M.p.: uncorrected. UV Spectra: *Hitachi-U-3400* spectrometer; λ_{max} (log ε) in nm. IR Spectra: *Vector-22-IR* spectrometer; KBr pellets; ν in cm^{-1}. ^{1}H-NMR: *Avance-400* spectrometer; $CDCl_3$ or (D_6)DMSO solns. with $SiMe_4$ as internal standard; δ in ppm, *J* in Hz. MS: *HP5859B* mass spectrometer; in *m*/*z* (rel. %). Elemental analyses: *EA1110*.

N^1,N^3-*Diaryluracils: General Procedure*. A mixture of diaryliodonium salt **1** (1.2 mmol), uracil or its derivatives **2** (0.5 mmol), K_2CO_3 (2 mmol), CuI (10 mol-%), and DMF (5 ml) was stirred under N_2 at 40° for 3–4 h. The mixture was diluted with sat. aq. NH_4Cl soln. (20 ml) and extracted with AcOEt (3 × 15 ml), the combined org. phase washed with brine, dried (Na_2SO_4), and evaporated, and the residue purified by prep. TLC (silica gel, cyclohexane/AcOEt 1:2): pure **3**.

*6-Methyl-1,3-diphenylpyrimidine-2,4(1*H,*3*H*)-dione* (**3a**): M.p. 182–183° ([5]: no m.p. reported). UV (EtOH): 266 (4.11). IR: 1712, 1662, 1594, 1489, 1408, 1368, 1235, 823, 764. ^{1}H-NMR ($CDCl_3$): 1.94 (*s*, 3 H); 5.86 (*s*, H–C(5)); 7.26–7.31 (*m*, 4 H); 7.38–7.41 (*m*, 1 H); 7.45–7.52 (*m*, 5 H). MS: 278 (57.02, M^+), 159 (100), 144 (34.80), 131 (48.31), 130 (51.50), 118 (32.61).

Table 3. N^3-*Arylation of 6-Methyluracil* (**2a**) *and* N^1-*Arylation of Uracil* (**2b**) *or Thymine* (**2c**). Conditions: all reactions were run with **1** (1.0 mmol), **2** (1.2 mmol), CuI (10 mol-%), NaOAc (2 mmol), and DMF (5 ml) under N_2 at 40° for 10 h.



Entry	**1**	Ar	**2**	Product	Yield[a]) [%]
1	**1a**	Ph	**2a**	**4a**	60
2	**1b**	4-MeC_6H_4	**2a**	**4b**	46
3	**1c**	4-ClC_6H_4	**2a**	**4c**	42
4	**1d**	4-BrC_6H_4	**2a**	**4d**	43
5	**1e**	$MeOC_6H_4$	**2a**	**4e**	40
6	**1a**	Ph	**2b**	**5a**	53
7	**1b**	4-MeC_6H_4	**2b**	**5b**	50
8	**1c**	4-ClC_6H_4	**2b**	**5c**	54
9	**1d**	4-BrC_6H_4	**2b**	**5d**	41
10	**1e**	4-$MeOC_6H_4$	**2b**	**5e**	45
11	**1a**	Ph	**2c**	**5f**	41
12[b])	**1b**	4-MeC_6H_4	**2c**	**5g**	46
13[c])	**1d**	4-BrC_6H_4	**2c**	**5h**	43

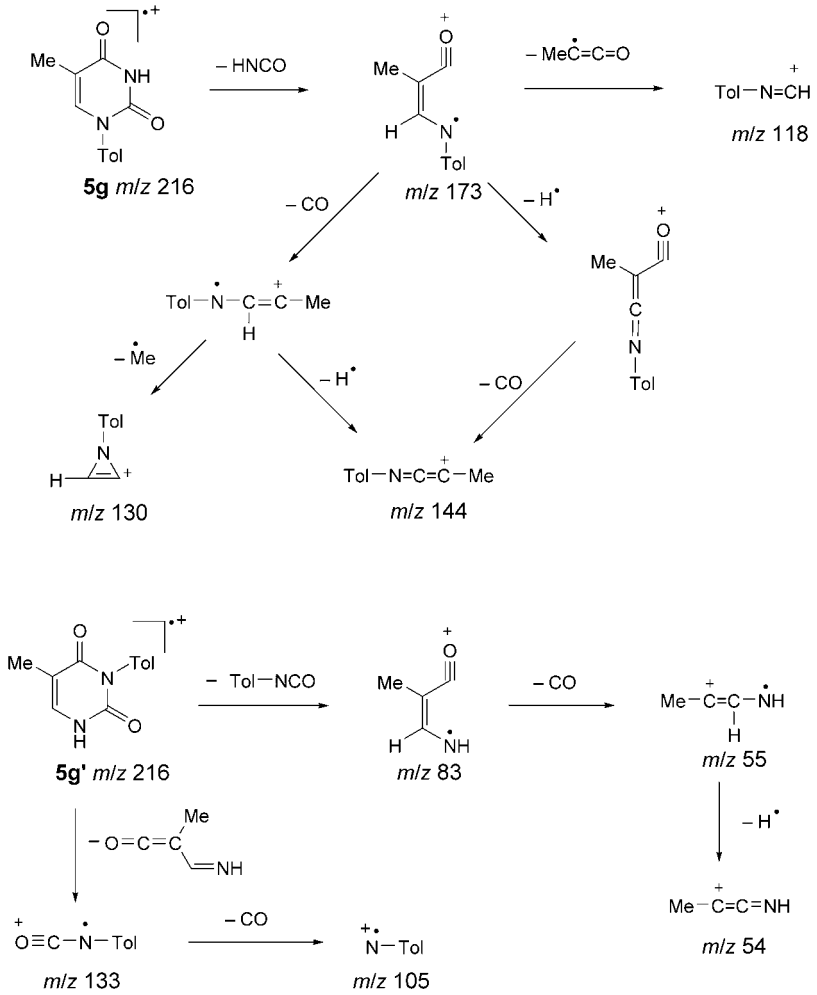
[a]) Isolated yield based on iodonium salt. [b]) N^3-(4-Methylphenyl)thymine (**5g′**) was obtained in 7% yield. [c]) N^3-(4-Bromophenyl)thymine (**5h′**) was obtained in 6% yield.

*6-Methyl-1,3-bis(4-methylphenyl)pyrimidine-2,4(1*H,*3*H*)-dione* (**3b**): M.p. 153–154°. UV (EtOH): 266 (4.09). IR: 1711, 1670, 1513, 1408, 1376, 818, 764. ^{1}H-NMR ($CDCl_3$): 1.93 (*s*, 3 H); 2.32 (*s*, 3 H); 2.40 (*s*, 3 H); 5.84 (*s*, H–C(5)); 7.14–7.17 (*m*, 4 H); 7.25–7.30 (*m*, 4 H). MS: 306 (41.46, M^+), 173 (100), 158 (25.72), 145 (37.71), 144 (37.56), 132 (32.49). Anal. calc. for $C_{19}H_{18}N_2O_2$: C 74.49, H 5.92, N 9.14; found: C 74.30, H 6.02, N 9.04.

*1,3-Bis(4-chlorophenyl)-6-methylpyrimidine-2,4(1*H,*3*H*)-dione* (**3c**): M.p. 137–139°. UV (EtOH): 264 (4.17). IR: 1717, 1675, 1491, 1415, 1375, 1088, 1016, 805. ^{1}H-NMR ($CDCl_3$): 1.95 (*s*, 3 H); 5.86 (*s*, H–C(5)); 7.21 (*d*, J = 8.6, 2 H); 7.24 (*d*, J = 8.6, 2 H); 7.44 (*d*, J = 8.40, 2 H); 7.49 (*d*, J = 8.4, 2 H). MS: 348 (15.04, $[M+2]^+$), 346 (23.25, M^+), 195 (33.29), 193 (100), 178 (25.50), 165 (20.40), 164 (24.11), 152 (25.78), 111 (23.10). Anal. calc. for $C_{17}H_{12}Cl_2N_2O_2$: C 58.79, H 3.48, N 8.06; found: C 58.65, H 3.46, N 8.17.

*1,3-Bis(4-bromophenyl)-6-methylpyrimidine-2,4(1*H,*3*H*)-dione* (**3d**): M.p. 191–193°. UV (EtOH): 265 (4.15). IR: 1715, 1671, 1489, 1412, 1368, 1070, 1013, 818, 798, 761. ^{1}H-NMR ($CDCl_3$): 1.94 (*s*, 3 H); 5.86 (*s*, H–C(5)); 7.14–7.18 (*m*, 4 H); 7.58–7.66 (*m*, 4 H). MS: (15.91, $[M+4]^+$), 436 (30.42, $[M+2]^+$), 434 (16.14, M^+), 239 (96.95), 237(100), 224 (21.42), 222 (22.69), 197 (17.01), 196 (29.01), 130 (61.52). Anal. calc. for $C_{17}H_{12}Br_2N_2O_2$: C 46.80, H 2.77, N 6.42; found: C 46.63, H 2.79, N 6.29.

Scheme. *MS Fragmentation of* N^1*-(4-Methylphenyl)thymine* (**5g**) *and* N^3*-(4-Methylphenyl)thymine* (**5g′**)



*1,3-Diphenylpyrimidine-2,4(1*H*,3*H*)-dione* (**3e**): M.p. 206–207° ([10a]: 207–210°). UV (EtOH): 271 (3.97). IR: 1717, 1682, 1594, 1490, 1429, 1379, 1303, 1182, 1075, 815, 763, 701. ^{1}H-NMR ($CDCl_3$): 5.99 (*d*, *J* = 8.0, 1 H); 7.29 (*m*, 2 H); 7.39–7.44 (*m*, 5 H); 7.47–7.52 (*m*, 4 H).

*1,3-Bis(4-methylphenyl)pyrimidine-2,4(1*H*,3*H*)-dione* (**3f**): M.p. 176–177°. UV (EtOH): 271 (3.95). IR: 1719, 1676, 1511, 1430, 1375, 1318, 1300, 1278, 822, 799, 761. ^{1}H-NMR ($CDCl_3$): 2.39 (*s*, 6 H); 5.96 (*d*, *J* = 8.0, H–C(5)); 7.16 (*d*, *J* = 8.2, 4 H); 7.29 (*d*, *J* = 8.2, 4 H); 7.38 (*d*, *J* = 8.0, H–C(6)). MS: 292 (45.69, M^+), 159 (100), 131 (28.34), 130 (66.46), 118 (17.15), 91 (54.69). Anal. calc. for $C_{18}H_{16}N_2O_2$: C 73.96, H 5.52, N 9.58; found: C 73.77, H 5.48, N 9.47.

1,3-Bis(4-chlorophenyl)pyrimidine-2,4(1 H,3 H)-dione (**3g**): M.p. 148–149°. UV (EtOH): 268 (4.02). IR: 1721, 1675, 1493, 1434, 1405, 1367, 1291, 1092, 1018, 827, 797. ^{1}H-NMR ($CDCl_3$): 6.00 (*d*, *J* = 8.0, H–C(5)); 7.22 (*d*, *J* = 8.0, 1 H); 7.33–7.39 (*m*, 4 H); 7.47 (*m*, 4 H). MS: 334 (21.48, $[M+2]^+$), 332 (32.87, M^+), 181 (32.93), 179 (100), 153 (18.36), 151 (40.65), 138 (15.36), 111 (20.34). Anal. calc. for $C_{16}H_{10}Cl_2N_2O_2$: C 57.66, H 3.00, N 8.40; found: C 57.50, H 2.95, N 8.25.

*5-Methyl-1,3-diphenylpyrimidine-2,4(1*H*,3*H*)-dione* (**3h**): M.p. 184–185° ([4]: no m.p. reported). UV (EtOH): 275 (4.04). IR: 1707, 1663, 1597, 1491, 1430, 1374, 1318, 1304, 762, 694. ^{1}H-NMR ($CDCl_3$): 2.03 (*s*, 3 H); 7.26 (*m*, 1 H); 7.29 (*m*, 2 H); 7.40 (*m*, 4 H); 7.45–7.49 (*m*, 4 H).

*5-Methyl-1,3-bis(4-methylphenyl)pyrimidine-2,4(1*H*,3*H*)-dione* (**3i**): M.p. 164–165°. UV (EtOH) 276 (4.02). IR: 1714, 1669, 1512, 1422, 1364, 1302, 1201, 1169, 1141, 1111, 816, 764, 745. ^{1}H-NMR ($CDCl_3$): 2.01 (*s*, 3 H); 2.39 (*s*, 6 H); 7.14 (*d*, $J = 8.3$, 4 H); 7.22–7.24 (*m*, 1 H); 7.28 (*d*, $J = 8.3$, 4 H). MS: 306 (61.45, M^+), 173 (100), 145 (26.88), 144 (79.47), 130 (35.39), 118 (11.92), 91 (37.17). Anal. calc. for $C_{19}H_{18}N_2O_2$: C 74.49, H 5.92, N 9.14; found: C 74.34, H 5.99, N 9.11.

*1,3-Bis(4-bromophenyl)-5-methylpyrimidine-2,4(1*H*,3*H*)-dione* (**3j**): M.p. 191–192°. UV (EtOH): 274 (4.08). IR: 1715, 1669, 1489, 1428, 1400, 1369, 1309, 1071, 1013, 890, 817, 763. ^{1}H-NMR ($CDCl_3$): 2.02 (*s*, 3 H); 7.15 (*m*, 2 H); 7.23 (*s*, 1 H); 7.28 (*m*, 2 H); 7.61 (*m*, 4 H). MS: 438 (18.24, $[M+4]^+$), 436 (36.05, $[M+2]^+$), 434 (19.00, M^+), 239 (58.06), 237 (60.23), 211 (12.47), 210 (29.63), 209 (14.11), 208 (27.85), 158 (48.03), 130 (100). Anal. calc. for $C_{17}H_{12}Br_2N_2O_2$: C 46.80, H 2.77, N 6.42; found: C 46.68, H 2.73, N 6.53.

N^3*-Aryl-6-methyluracils,* N^1*-Aryluracils, and* N^1*-Arylthymines: General Procedure.* A mixture of diaryliodonium salt **1** (1 mmol), uracil or its derivatives **2** (1.2 mmol), NaOAc (2 mmol), CuI (10 mol-%), and DMF (5 ml) was stirred under N_2 at 40° for 10 h. The mixture was diluted with sat. aq. NH_4Cl soln. (20 ml) and extracted with AcOEt (3×15 ml), the combined org. phase washed with brine, dried (Na_2SO_4), and evaporated, and the residue purified by prep. TLC (cyclohexane/AcOEt 1:2): **4** or **5**.

*6-Methyl-3-phenylpyrimidine-2,4(1*H*,3*H*)-dione* (**4a**): M.p. 243–245°. ([12]: 224–250°). UV (EtOH): 261 (4.02). UV (pH 13): 285 (4.08). IR: 3223, 3185, 3114, 1711, 1657, 1506, 1488, 1457, 1418, 1353, 1209, 1121, 823, 774, 703. ^{1}H-NMR ($CDCl_3$): 2.06 (*s*, 3 H); 5.66 (*s*, H–C(5)); 7.23 (*m*, 2 H); 7.43–7.51 (*m*, 3 H); 9.41 (br., NH).

*6-Methyl-3-(4-methylphenyl)pyrimidine-2,4(1*H*,3*H*)-dione* (**4b**): M.p. 264° (dec.) ([9]: no m.p. reported). UV (EtOH): 261 (3.99). UV (pH 13): 285 (4.04). IR: 3173, 1738, 1648, 1520, 1411, 1354, 1212, 1122, 821, 766, 718. ^{1}H-NMR ($CDCl_3$): 2.12 (*s*, 3 H); 2.39 (*s*, 3 H); 5.66 (*s*, H–C(5)); 7.10 (*d*, $J = 8.2$, 2 H); 7.29 (*d*, $J = 8.2$, 2 H); 8.88 (br., NH). MS: 216 (53.61, M^+), 133 (100), 132 (19.82), 105 (18.92), 104 (23.68), 84 (27.57).

*3-(4-Chlorophenyl)-6-methylpyrimidine-2,4(1*H*,3*H*)-dione* (**4c**): M.p. 282° (dec.) ([13]: 342° (dec.)). UV (EtOH): 261 (4.05). UV (pH 13): 285 (4.11). IR: 3230, 3179, 3096, 1738, 1647, 1584, 1497, 1418, 1352, 1214, 1124, 1093, 1020, 831, 765, 717. ^{1}H-NMR ($CDCl_3$): 2.16 (*s*, 3 H); 5.67 (*s*, H–C(5)); 7.17 (*d*, $J = 8.8$, 2 H); 7.46 (*d*, $J = 8.8$, 2 H); 8.61 (br., NH). MS: 238 (25.11, $[M+2]^+$), 236 (74.35, M^+), 153 (100), 125 (27.44), 83 (62.33).

*3-(4-Bromophenyl)-6-methylpyrimidine-2,4(1*H*,3*H*)-dione* (**4d**): M.p. 320° (dec.). UV (EtOH): 261 (4.03). UV (pH 13): 285 (4.08). IR: 3225, 3176, 3092, 1736, 1647, 1491, 1414, 1353, 1123, 1071, 1016, 823, 765, 714. ^{1}H-NMR ((D_6)DMSO): 2.09 (*s*, 3 H); 5.57 (*s*, H–C(5)); 7.19 (*d*, $J = 8.8$, 2 H); 7.64 (*d*, $J = 8.8$, 2 H); 11.30 (br., NH). MS: 282 (74.27, $[M+2]^+$), 280 (75.03, M^+), 199 (84.86), 197 (84.93), 90 (100), 83 (72.32), 68 (91.67), 63 (73.54), 55 (41.32). Anal. calc. for $C_{11}H_9BrN_2O_2$: C 46.98, H 3.23, N 9.96; found: C 46.79, H 3.16, N 9.85.

*3-(4-Methoxyphenyl)-6-methylpyrimidine-2,4(1*H*,3*H*)-dione* (**4e**): M.p. 249–251°. UV (EtOH): 263 (4.04). UV (pH 13): 283 (4.09). IR: 3236, 3180, 3087, 1734, 1653, 1520, 1413, 1304, 1261, 1176, 1035, 767, 647. ^{1}H-NMR ((D_6)DMSO): 2.08 (*s*, 3 H); 3.78 (s, 3 H); 5.53 (*s*, H–C(5)); 6.97 (*d*, $J = 8.8$, 2 H); 7.08 (*d*, $J = 8.8$, 2 H); 9.28 (br., NH). MS: 232 (30.22, M^+), 149 (100), 134 (39.43), 106 (22.34). Anal. calc. for $C_{12}H_{12}N_2O_3$: C 62.06, H 5.21, N 12.06; found: C 61.87, H 5.11, N 12.23.

*1-Phenylpyrimidine-2,4(1*H*,3*H*)-dione* (**5a**): M.p. 242–244° ([14]: 246°). UV (EtOH): 268 (4.05). UV (pH 13): 268 (3.94). IR: 3161, 3098, 3053, 1744, 1693, 1628, 1601, 1500, 1441, 1423, 1384, 1299, 1283, 1258, 825, 758, 688. ^{1}H-NMR ((D_6)DMSO): 5.67 (*dd*, $J = 8.0$, 2.0, H–C(5)); 7.41–7.45 (*m*, 3 H); 7.50 (*m*, 2 H); 7.71 (*d*, $J = 8.0$, 1 H), 11.44 (br., NH).

*1-(4-Methylphenyl)pyrimidine-2,4(1*H*,3*H*)-dione* (**5b**): M.p. 225–227° ([15]: 226.5–228°). UV (EtOH): 268 (4.03). UV (pH 13): 267 (3.93). IR: 3158, 3100, 3135, 1742, 1691, 1516, 1448, 1384, 1297, 1260, 825, 813, 725, 712. ^{1}H-NMR ((D_6)DMSO): 2.35 (*s*, 3 H); 5.65 (*dd*, $J = 8.0$, 2.0, H–C(5)); 7.29 (*s*, 4 H); 7.66 (*d*, $J = 8.0$, 1 H); 11.41 (br., NH).

*1-(4-Chlorophenyl)pyrimidine-2,4(1*H*,3*H*)-dione* (**5c**): M.p. 253–255° ([6]: 258°). UV (EtOH): 263 (4.18). UV (pH 13): 263 (4.08). IR: 3088, 1718, 1664, 1539, 1450, 1382, 1291, 1274, 1090, 981, 820, 760, 714. ^{1}H-NMR ((D_6)DMSO): 5.68 (*d*, $J = 7.6$, H–C(5)); 7.47 (*m*, 2 H); 7.58 (*m*, 2 H); 7.71 (*d*, $J = 7.6$, H–C(6)); 11.45 (br., NH).

*1-(4-Bromophenyl)pyrimidine-2,4(1*H*,3*H*)-dione* (**5d**): M.p. 272–274° ([16]: 275–276°). UV (EtOH): 264 (4.12). UV (pH 13): 265 (4.01). IR: 3107, 3022, 1718, 1660, 1495, 1472, 1383, 1291, 1077, 979, 819, 746, 712. ^{1}H-NMR ((D_6)DMSO): 5.68 (*dd*, $J = 8.0$, 2.4, H–C(5)); 7.40 (*m*, 2 H); 7.67–7.72 (*m*, 3 H); 11.47 (br., NH).

*1-(4-Methoxyphenyl)pyrimidine-2,4(1*H*,3*H*)-dione* (**5e**): M.p. 228–229° ([15]: 230.5–231.5°). UV (EtOH): 273 (4.10). UV (pH 13): 273 (3.99). IR: 3022, 1688, 1655, 1513, 1494, 1464, 1248, 1171, 977, 827. ^{1}H-NMR

((D$_6$)DMSO): 3.79 (*s*, 3 H); 5.66 (*d*, *J* = 8.0, 1 H); 7.02 (*d*, *J* = 8.7, 2 H); 7.48 (*d*, *J* = 8.7, 2 H); 7.68 (*d*, *J* = 8.0, 1 H); 11.43 (br., NH).

*5-Methyl-1-phenylpyrimidine-2,4(1*H*,3*H*)-dione* (**5f**): M.p. 198–200° ([17]: 199°). UV (EtOH): 273 (4.09). UV (pH 13): 274 (3.99). IR: 3168, 3102, 1704, 1665, 1596, 1491, 1447, 1372, 1319, 1302, 1280, 1037, 761, 692. ^{1}H-NMR ((D$_6$)DMSO): 1.81 (*d*, *J* = 1.2, 3 H); 7.40–7.43 (*m*, 3 H); 7.47–7.51 (*m*, 2 H); 7.61 (*d*, *J* = 1.2, H–C(6)); 11.42 (br., NH).

*5-Methyl-1-(4-methylphenyl)pyrimidine-2,4(1*H*,3*H*)-dione* (**5g**): M.p. 216–217°. UV (EtOH): 275 (4.07). UV (pH 13): 275 (3.97). IR: 3156, 3103, 1702, 1669, 1517, 1465, 1425, 1367, 1299, 1284, 1178, 911, 823, 795, 756, 657. ^{1}H-NMR ((D$_6$)DMSO): 1.80 (*d*, *J* = 1.2, 3 H); 2.50 (*s*, 3 H); 7.27 (*s*, 4 H); 7.56 (*d*, *J* = 1.2, H–C(6)); 11.38 (br., NH). MS: 216 (95.41, M^+), 173 (59.51), 144 (100), 130 (43.36), 118 (14.17), 91 (43.05). Anal. calc. for $C_{12}H_{12}N_2O_2$: C 66.66, H 5.59, N 12.95; found: C 66.44, H 5.66, N 12.77.

*5-Methyl-3-(4-methylphenyl)pyrimidine-2,4(1*H*,3*H*)-dione* (**5g′**): M.p. 246–248° ([18]: no m.p. reported). UV (EtOH): 264 (4.05). UV (pH 13): 292 (4.10). IR: 3273, 3069, 2925, 1712, 1659, 1479, 1433, 1219, 1189, 818, 767. ^{1}H-NMR ((D$_6$)DMSO): 1.80 (*s*, 3 H); 2.34 (*s*, 3 H); 7.06 (*d*, *J* = 8.2, 2 H); 7.24 (*d*, *J* = 8.0, 2 H); 7.39(*m*, 1 H); 11.01 (br., NH). MS: 216 (75.27, M^+), 133 (100), 105 (14.67), 83 (11.53), 55 (51.92), 54 (18.72).

*1-(4-Bromophenyl)-5-methylpyrimidine-2,4(1*H*,3*H*)-dione* (**5h**): M.p. 240–241°. UV (EtOH): 272 (4.12). UV (pH 13): 273 (4.02). IR: 3161, 3093, 1718, 1661, 1491, 1403, 1363, 1313, 1294, 1067, 1010, 915, 818, 715. ^{1}H-NMR ((D$_6$)DMSO): 1.80 (*d*, *J* = 1.0, 3 H); 7.40 (*d*, *J* = 8.8, 2 H); 7.61 (*d*, *J* = 1.2, H–C(6)); 7.69 (*d*, *J* = 8.8, 2 H); 11.46 (br., NH). MS: 282 (45.80, $[M+2]^+$), 280 (46.19, M^+), 239 (33.27), 237 (36.04), 210 (29.38), 208 (29.81), 158 (35.19), 157 (20.21), 130 (100). Anal. calc. for $C_{11}H_9BrN_2O_2$: C 46.98, H 3.23, N 9.96; found: C 47.14, H 3.35, N 9.94.

*3-(4-Bromophenyl)-5-methylpyrimidine-2,4(1*H*,3*H*)-dione* (**5h′**): M.p. 262° (dec.). UV (EtOH): 265 (4.08). UV (pH 13): 294 (4.14). IR: 3236, 2969, 1716, 1654, 1487, 1424, 1225, 1015, 769. ^{1}H-NMR ((D$_6$)DMSO): 1.81 (*s*, 3 H); 7.20 (*d*, *J* = 8.5, 2 H); 7.42 (*d*, *J* = 6.0, 1 H); 7.64 (*d*, *J* = 8.5, 2 H); 11.05 (br., NH). MS: 282 (16.24, $[M+2]^+$), 280 (16.27, M^+), 199 (10.34), 197 (10.78), 90 (18.23), 83 (30.85), 55 (100), 54 (24.93).

REFERENCES

[1] D. J. Brown, in 'Comprehensive Heterocyclic Chemistry – The Structure, Reaction, Synthesis and Uses of Heterocyclic Compounds', Eds. A. R. Katritzky and C. B. Reese, Pergamon, 1984, Vol. 3, p. 57.

[2] D. Bergstrom, P. Beal, A. Husain, R. Lind, J. Jenson, *J. Am. Chem. Soc.* **1989**, *111*, 374.

[3] I. Matsurra, T. Ueda, N. Murakmi, S. Nagai, J. Sakakibara, *J. Chem. Soc., Perkin Trans. 1*, **1991**, 2821.

[4] L. Gapuano, M. Kussler, H. R. Kirn, *Ann. Univ. Sarav., Math. Naturwiss. Fak.* **1981**, *16*, 7 (*Chem. Abstr.* **1982**, *96*, 85503w).

[5] S. Shigeo, I. Sho, S. Eisuke, O. Akio, K. Masahiro, Japan. Kokai 7436, 686 (*Chem. Abstr.* **1974**, *81*, 63657n).

[6] N. W. Gabel, S. B. Binkley, *J. Org. Chem.* **1958**, *23*, 643.

[7] H. Singh, P. Singh, P. Aggarwal, S. Kumar, *J. Chem. Soc., Perkin Trans. 1* **1993**, 731.

[8] G. Bernath, G. Stajer, A. E. Szabo, Z. Szoke-Molnar, P. Sohar, G. Argay, A. Kalman, *Tetrahedron* **1987**, *43*, 1921.

[9] H. Josef, M. Vladimir, S. Vojeslav, *Sb. Ved. Pr., Vys. Sk. Chemickotechnol. Pardubice* **1978**, *39*, 11 (*Chem. Abstr.* **1979**, *91*, 174663n).

[10] a) T. Maruyama, K. Fujiwara, M. Fukuhara, *J. Chem. Soc., Perkin Trans. 1* **1995**, 733; b) J. You, S. Chen, Y. Wang, Y. Chen, *J. Chem. Res.(S)* **2000**, 466.

[11] M. Xia, Z.-C. Chen, *J. Chem. Res.(S)* **1999**, 328; M. Xia, Z.-C. Chen, *Synth. Commun.* **1999**, *29*, 2457; L. Wang, Z.-C. Chen, *Synth. Commun.* **2000**, *30*, 3607; L. Wang, Z.-C. Chen, *J. Chem. Res.(S)* **2000**, 372; M. Xia, Z.-C. Chen, *Synth. Commun.* **2000**, *30*, 1281; T. Zhou, Z.-C. Chen, *J. Chem. Res.(S)* **2000**, 474; T. Zhou, Z.-C. Chen, *Synth. Commun.* **2001**, *31*, 3289; T. Zhou, Z.-C. Chen, *Synth. Commun.* **2002,** *32*, 887; T. Zhou, Z.-C. Chen, *J. Chem. Res.* **2004**, 404.

[12] D. Shugar, J. Fox, *Biochim. Biophys. Acta* **1952**, *9*, 199.

[13] J. M. Rice, G. O. Dudek, M. Barber, *J. Am. Chem. Soc.* **1965**, *87*, 4569.

[14] B. Chartamra, A. S. Jones, *J. Chem. Soc.* **1963**, 811.

[15] R. Baltrusis, I. Mariosius, *Khim. Geterotsikl. Soedin* **1968**, 954.

[16] S. Shigeo, H. Kosaka, A. Tetsuji, *Chem. Pharm. Bull.* **1974**, *22*, 189.

[17] G. Shaw, R. N. Warrener, *J. Chem. Soc.* **1958**, 157.

[18] T. S. Safonova, V. M. Nesterov, U.S.S.R. 170, 601 (*Chem. Abstr.* **1965**, *63*, p 8376h).

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