

Lithiation in the Synthesis of 5-Pyrimidinyl Ketones

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A method for the preparation of 2-substituted 5-pyrimidinyl aryl or heteroaryl ketones from 5-bromo-2-methylthiopyrimidine-4-carboxylic acid is described. The latter was lithiated and reacted with an aroyl or heteroaroaryl chloride to give the corresponding 5-acylpyrimidine-4-carboxylic acid which was readily decarboxylated on heating.

Relatively few 5-acylpyrimidines have been described. Primary syntheses by cyclization reactions leading to pyrimidines are known,¹ but the formation of isomeric mixtures is difficult to avoid.² Acylation by direct substitution at the 5-position in the pyrimidine ring using electrophilic carbon reactants normally requires the presence of two or three electron-releasing substituents.³ For our continued biological studies of substituted 2(1*H*)-pyrimidinones,⁴ we needed a more versatile route for the preparation of 5-acyl derivatives. The method of preparation described below was suggested by the effect of carboxy and amide groups on the control of *ortho* metalation in aromatic derivatives, and the influence of these groups on the reactivity of the metalated species.^{5,6}

The 4-carboxy derivative **2** would seem to be a suitable substrate for *ortho* lithiation at C-5. The 5-bromo derivative **1** was, however, more readily available. It was conveniently prepared in a cyclic condensation reaction between mucobromic acid, which is an aldehydoketone equivalent, and an *S*-methyl-thiuronium salt.⁷ The 5-bromo derivative underwent metal-halogen exchange in tetrahydrofuran (THF) at -95°C when it was treated with two equivalents of butyllithium. The metalation proceeded well; quenching the metalated species with water produced the dehalogenated acid **2** in 78% yield.

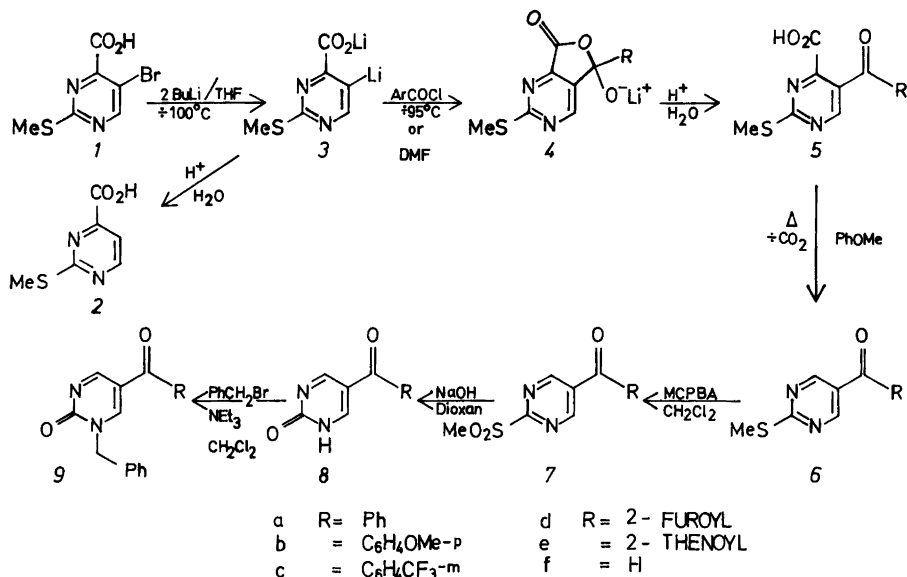
The 4-carboxy group served to facilitate the metal-halogen exchange at C-5 as well as to sta-

bilize the metalated species. An important function of the lithium carboxylate group in the reaction with the carbonyl reactant was to stop the reaction at the ketone stage by protecting the carbonyl group as a cycloadduct **4**. This allowed the use of aroyl chlorides in the ketone synthesis. The formation of ketone **5** extended previous findings that lithium *o*-benzoates and their congeners with aroyl chlorides yield *o*-aroylbenzoic acids, whereas aryllithium reagents usually yield tertiary alcohols.⁸

The formyl derivative **5f** was obtained when the metalated species was treated with *N,N*-dimethylformamide. Formation of ketones with an aliphatic side chain in the reaction between **3** and an aliphatic acid chloride, however, is unlikely when the aliphatic acid derivative carries an α hydrogen atom because of aldol type reactions under the strongly basic conditions in the reaction.

The carboxy group in product **5** is in an activated pyrimidine position and is additionally activated by the adjacent acyl group. As previously found in related systems,⁹ the carboxy group was smoothly removed when **5** was heated in anisole. The purification of decarboxylated product **6** was easier to effect than the purification of **5**. Therefore, the crude product **5** was used directly for the decarboxylation reaction. The overall yield for the reaction sequence **1**→**6** was 30–40%. Chemoselective oxidation of the sulfide **6** by means of *m*-chloroperbenzoic acid gave the sulfone **7** which was readily hydrolyzed under alkaline conditions to the 2(1*H*)-pyrimidinone **8**. The latter reacted with benzyl bromide under alkaline

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conditions to form the *N*-benzylated product 9.

The assignment of the ¹H-chemical shifts in the 2-furoyl and 2-thenoyl derivatives was based on relative shifts and coupling constants reported for 2-formyl- and 2-acetyl-furan and thiophene.¹⁰ H-5 was the low field proton in both the furan and thiophene rings; *J*_{3,4} was the largest coupling constant in the furan and *J*_{4,5} in the thiophene derivatives.

Experimental

The ¹H NMR spectra were recorded at 60 MHz and the ¹³C NMR spectra at 15 MHz. The mass spectra were recorded at 70 eV and are reported as *m/z* (% rel.int.).

5-Bromo-2-methylthiopyrimidine-4-carboxylic acid 1. ¹³C NMR (DMSO-*d*₆): δ 14.0 (SMe), 110.2 (C-5, *J*_{C5,H6} 4.9 Hz), 158.1 (C-2, *J*_{C2,H6} 4.8 Hz), 160.7 (C-6, *J*_{C6,H6} 196.2 Hz), 169.9 (CO₂H), 170.6 (C-4, *J*_{C4,H6} 5 Hz).

2-Methylthiopyrimidine-4-carboxylic acid 2. Butyllithium in hexane (1.6 M; 15 ml, 24 mmol) was added dropwise from a syringe to a stirred solution of 5-bromo-2-methylthiopyrimidine-4-carboxylic acid (3.00, 12 mmol) in dry THF (100 ml) at -90°C under N₂. The reddish-brown mixture

which resulted was stirred at ≈80°C, for 80 min, poured into ice-cold 1M HCl (40 ml), and the mixture stirred at ambient temperature for 1 h. The organic phase was separated, the aqueous phase extracted with chloroform (4 × 50 ml) and the combined organic solution evaporated. The residue was extracted into chloroform (200 ml), and the chloroform solution washed before extraction with 1M NaOH (5 × 50 ml). Acidification of the NaOH solution precipitated the product which was washed and recrystallized from water (charcoal); yield 1.60 g (78%), m.p. 213–215°C. The physical data were in agreement with those for the product obtained by hydrolysis of 4-cyano-2-methylthiopyrimidine.¹¹

General procedure for the preparation of 5-acyl-2-methylthiopyrimidine-4-carboxylic acids 5. Butyllithium in hexane (1.6 M; 15 ml, 24 mmol) was added dropwise from a syringe to a stirred solution of 5-bromo-2-methylthiopyrimidine-4-carboxylic acid (3.00 g, 12 mmol) in dry THF at -90°C under N₂. The reddish-brown mixture was stirred at ≈80°C for 80 min, then cooled to -90°C. Aroyl chloride (12 mmol) in dry THF (6 ml) was added dropwise from a syringe, the mixture was stirred at -90°C for 15 min, at ≈80°C for 2 h, allowed to reach -50°C and poured into 1M HCl (40 ml) with stirring. The organic phase

was separated, the aqueous phase extracted with chloroform (5 × 50 ml) and the combined organic solutions evaporated. The oily residue was extracted into chloroform (200 ml), the chloroform solution shaken with water (2 × 50 ml) and extracted with 1M NaOH (5 × 50 ml). Acidification of the NaOH extracts precipitated the solid product. The crude product was subjected to decarboxylation as described below, or further purified by recrystallization.

5-Benzoyl-2-methylthiopyrimidine-4-carboxylic acid 5a. Compound *5a* was obtained from benzoyl chloride in 36% yield, m.p. 200°C (MeOH/H₂O). Anal. C₁₃H₁₀N₂O₃S: C, H. ¹H NMR (DMSO-*d*₆): δ 2.65 (SMe), 7.6–7.9 (Ph), 8.75 (H-6). IR (KBr): 1711 (CO₂H) and 1671 cm⁻¹ (CO). MS: 274 (15, M), 230 (100), 229 (19), 215 (6), 184 (13), 105 (68).

5-(4-Anisoyl)-2-methylthiopyrimidine-4-carboxylic acid 5b. Compound *5b* was obtained from 4-anisoyl chloride in 35% yield, m.p. 215°C (MeOH). Anal. C₁₄H₁₂N₂O₄S: C, H. ¹H NMR (DMSO-*d*₆): δ 2.65 (SMe), 3.80 (OMe), 7.11 and 7.78 (Ph, dd), 8.90 (H-6). ¹³C NMR (DMSO-*d*₆): δ 13.7 (SMe), 35.2 (OMe), 114.2–131.9 and 163.7 (C₆H₄), 126.9 (C-5, *J*_{C5,H6} 6.8 Hz), 156.3 (C-2), 157.9 (C-6, *J*_{C6,H6} 187.5 Hz), 165.0 (COOH), 173.1 (C-4), 190.6 (COAr). IR (KBr): 1710 (COOH) and 1664 (CO-Ar). MS: 304 (21, M), 261 (16), 260 (86), 259 (40), 232 (18), 135 (100).

2-Methylthio-5-(3-trifluoromethylbenzoyl)pyrimidine-4-carboxylic acid 5c. Compound *5c* was obtained from 3-trifluoromethylbenzoyl chloride. The crude product was decarboxylated without further purification.

5-(2-Furoyl)-2-methylthiopyrimidine-4-carboxylic acid 5d. Compound *5d* was obtained from 2-furoyl chloride. The crude product (77%) was decarboxylated without further purification. ¹H NMR (DMSO-*d*₆): δ 2.60 (SMe), 6.68 (H-4', dd), 7.40 (H-3, dd), 8.15 (H-5', dd), 9.05 (H-6).

2-Methylthio-5-(2-thenoyl)pyrimidine-4-carboxylic acid 5e. Compound *5e* was obtained from 2-thenoyl chloride. The crude product (75%) was decarboxylated without further purification. ¹H

NMR (1:1, CDCl₃-DMSO-*d*₆): δ 2.60 (SMe), 7.10 (H-4', dd), 7.50 (H-3', d), 7.90 (H-5', d), 8.80 (H-6).

5-Formyl-2-methylthiopyrimidine-4-carboxylic acid 5f. 5-Bromo-2-methylthiopyrimidine-4-carboxylic acid (12 mmol) was metalated as above and dry dimethylformamide (41 mmol) in THF (4 ml) was added at -85°C from a syringe. The mixture was stirred at -65°C for 4 h, allowed to reach 0°C and poured into 2 M HCl with stirring. The phases were separated and the dried (MgSO₄) organic solution evaporated leaving a yellow crystalline material; yield 67%, m.p. 171°C (H₂O). Anal. C₇H₆N₂O₃S: C, H. ¹H NMR (1:1, CDCl₃/DMSO-*d*₆): δ 2.65 (SMe), 9.05 (H-6), 10.50 (CHO). MS: 198 (9, M), 170 (100), 155 (22), 154 (41), 153 (12), 152 (18).

General procedure for the preparation of 5-aryloxy-2-methylthio-pyrimidine 6. A solution of the acid *5* (5 mol) in anisole (20 ml) was heated under reflux for ~2.5 h. The progress of the decarboxylation was monitored by TLC. The solvent was removed at reduced pressure and the residual product purified by recrystallization.

5-Benzoyl-2-methylthiopyrimidine 6a. Yield 98%, m.p. 100°C (EtOH). Anal. C₁₂H₁₀N₂O₂S: C, H. ¹H NMR (CDCl₃): δ 2.60 (SMe), 7.5–7.8 (Ph), 8.90 (2H, H-4,6, s). IR (KBr): 1653 cm⁻¹ (COPh). MS: 230 (100, M), 229 (11), 184 (12), 155 (6), 153 (10).

5-(4-Anisoyl)-2-methylthiopyrimidine 6b. Yield 92%, m.p. 105°C (MeOH/H₂O). Anal. C₁₃H₁₂N₂O₂S: C, H. ¹H NMR (CDCl₃): δ 2.60 (SMe), 3.90 (OMe), 7.11 and 7.78 (C₆H₄, dd), 8.90 (2H, H-4,6, s). IR (KBr): 1640 cm⁻¹ (CO). MS: 260 (100, M), 259 (7), 229 (4), 214 (6), 153 (8), 135 (64).

2-Methylthio-5-(3-trifluoromethylbenzoyl)pyrimidine 6c. The overall yield for the reactions *1* → *6c* was 43%, m.p. 112°C (EtOH). Anal. C₁₃H₉F₃N₂O₂S: C, H. ¹H NMR (CDCl₃): δ 2.60 (SMe), 7.5–8.1 (C₆H₃), 8.95 (2H, H-4,6, s). IR (KBr): 1635 cm⁻¹ (CO). MS: 298 (100, M), 279 (3), 252 (14), 198 (4), 173 (30), 153 (10), 145 (28).

5-(2-Furoyl)-2-methylthiopyrimidine 6d. The overall yield for the reactions $1 \rightarrow 6d$ was 26%, m.p. 76°C (EtOH). Anal. $C_{10}H_8N_2O_2S$: C, H. 1H NMR ($CDCl_3$): δ 2.60 (SMe), 6.68 (H-4', dd, $J_{3,4}$ 3.6 Hz, $J_{4,5}$ 1.7 Hz), 7.40 (H-3', dd, $J_{3,5}$ 0.8 Hz), 7.78 (H-5', dd), 9.15 (2H, H-4,6). IR (KBr): 1630 cm^{-1} (CO). MS: 220 (100, M), 205 (8), 191 (6), 174 (15), 118 (5), 95 (28).

2-Methylthio-5-(2-thenoyl)pyrimidine 6e. The overall yield for the reactions $1 \rightarrow 6e$ was 33%, m.p. 103°C (EtOH). Anal. $C_{10}H_8N_2OS_2$: C, H. 1H NMR ($CDCl_3$): δ 2.60 (SMe), 7.23 (H-4', dd), 7.68 (H-3', dd, $J_{3,4}$ 4.90 Hz, $J_{3,5}$ 1.95 Hz), 7.82 (H-5', dd, $J_{4,5}$ 5.38 Hz, $J_{3,5}$ 1.96 Hz), 8.95 (2H, H-4,6). IR (KBr): 1622 cm^{-1} (CO). MS: 236 (100, M), 221 (9), 190 (46), 116 (7), 111 (43).

5-Formyl-2-methylthiopyrimidine 6f. The overall yield for the reactions $1 \rightarrow 6f$ was 26%; m.p. 84°C (sublim). Anal. $C_8H_6N_2OS$: C, H. 1H NMR ($CDCl_3$): δ 2.60 (SMe), 8.90 (2H, H-4,6, s), 10.00 (CHO, s). IR (KBr) 1692 cm^{-1} (CO). MS: 154 (100, M), 153 (17), 112 (4), 109 (9), 108 (26).

General procedure for the preparation of 5-aroyle-2-methyl-sulfonylpyrimidines 7. A solution of the sulfide 6 (3 mmol) and *m*-chloroperbenzoic acid (9 mmol) in dichloromethane (80 ml) was stirred at ambient temperature for ~ 2.5 h. The progress of the oxidation was monitored by TLC. When the reaction was completed, the mixture was shaken with aqueous sodium bisulfite (2×30 ml), with saturated $NaHCO_3$ (3×30 ml), then the washed and dried ($MgSO_4$) solution evaporated. Final purification was by recrystallization.

5-Benzoyl-2-methylsulfonylpyrimidine 7a. Yield 90%, m.p. 156°C (2-PrOH). Anal. $C_{12}H_{10}N_2O_3S$: C, H. 1H NMR ($DMSO-d_6$): δ 3.50 ($MeSO_2$), 7.4–7.9 (Ph), 9.20 (2H, H-4,6). IR (KBr): 1657 (CO), 1376 and 1181 cm^{-1} (SO_2). MS: 262 (33, M), 247 (5), 198 (8), 184 (7), 105 (100).

5-(4-Anisoyl)-2-methylsulfonylpyrimidine 7b. Yield 75%, m.p. 191°C (2-PrOH). Anal. $C_{13}H_{12}N_2O_4S$: C, H. 1H NMR (1:1, $CDCl_3/DMSO-d_6$): δ 3.50 ($MeSO_2$), 3.90 (OMe), 7.11 and 7.78 (C_6H_4 , dd), 9.30 (2H, H-4,6). MS: 292 (36, M), 213 (12), 136 (9), 135 (100), 92 (16).

2-Methylsulfonyl-5-(3-trifluoromethylbenzoyl)-pyrimidine 7c. Yield 93%, m.p. 199°C (2-Anal. $C_{13}H_9F_3N_2O_3S$: C, H. 1H NMR (1:1, $CDCl_3/DMSO-d_6$): δ 3.50 (SO_2Me), 7.8–8.2 (C_6H_4), 9.30 (2H, H-4,6). MS: 330 (14, M), 311 (5), 267 (10), 266 (16), 173 (100).

5-(2-Furoyl)-2-methylsulfonylpyrimidine 7d. Yield 57%, m.p. 150°C (2-PrOH). Anal. $C_{10}H_8N_2O_4S$: C, H. 1H NMR ($DMSO-d_6$): δ 3.50 ($MeSO_2$), 6.88 (H-4', dd), 7.68 (H-3', dd, $J_{3,4}$ 2.55 Hz, $J_{3,5}$ 1.36 Hz), 8.25 (H-5', dd, $J_{4,5}$ 1.95 Hz, $J_{3,5}$ 1.36 Hz), 9.47 (2H, H-4,6). MS: 252 (23, M), 224 (5), 189 (5), 188 (6), 173 (56), 95 (100).

2-Methylsulfonyl-5-(2-thenoyl)pyrimidine 7e. Yield 95%, m.p. 250°C (MeOH). Anal. $C_{10}H_8N_2O_3S_2$: C, H. 1H NMR ($DMSO-d_6$): δ 3.50 ($MeSO_2$), 7.35 (H-4', dd), 7.93 (H-3', dd, $J_{3,4}$ 3.91 Hz, $J_{3,5}$ 1.95 Hz), 8.27 (H-5', dd, $J_{4,5}$ 4.89 Hz, $J_{3,5}$ 1.95 Hz), 9.43 (2H, H-4,6). MS: 268 (55, M), 205 (7), 190 (6), 189 (38), 111 (100).

General procedure for the preparation of 5-aroyle-2(1H)-pyrimidinones 8. 2 M NaOH (10 ml) was added to a suspension of the sulfone 7 (1.86 mmol) in dioxane/water (1:1; 20 ml). The mixture was stirred at ambient temperature until a clear solution resulted (15 min). On acidification with HCl, the product precipitated and was purified by recrystallization.

5-Benzoyl-2-(1H)-pyrimidinone 8a. Yield 63%, m.p. 244°C (MeOH). Anal. $C_{11}H_8N_2O_2$: C, H. 1H NMR (1:1, $CDCl_3/DMSO-d_6$): δ 7.5–7.7 (Ph), 8.60 (2H, H-4,6). MS: 200 (100, M), 199 (43), 172 (13), 171 (31).

5-(4-Anisoyl)-2(1H)-pyrimidinone 8b. Yield 90%, m.p. 252°C (MeOH). Anal. $C_{12}H_{10}N_2O_3$: C, H. 1H NMR ($DMSO-d_6$): δ 3.90 (MeO), 7.0–7.2 (C_6H_4), 9.20 (2H, H-4,6). IR (KBr): 1630 cm^{-1} (COAr). MS: 230 (78, M), 229 (17), 215 (6), 202 (9), 199 (39), 135 (100).

5-(3-Trifluoromethylbenzoyl)-2(1H)-pyrimidinone 8c. Yield 72%, m.p. 194°C (H_2O). Anal. $C_{12}H_7F_3N_2O_2$: C, H. 1H NMR ($DMSO-d_6$): δ 7.8–8.1 (C_6H_4), 8.15 (2H, H-4,6). MS: 268 (35, M), 267 (5), 249 (12), 239 (7), 199 (100).

5-(2-Furoyl)-2(1H)-pyrimidinone 8d. Yield 67%, m.p. 248°C (MeOH). Anal. $C_9H_6N_2O_3$; C,H. 1H NMR (DMSO- d_6): δ 6.70 (H-4', dd), 7.50 (H-3', d), 8.00 (H-5', d), 8.90 (2H, H-4,6). MS: 190 (36, M), 162 (39), 134 (10), 123 (14), 36 (100).

5-(2-Thenoyl)-2(1H)-pyrimidinone 8e. Yield 95%, m.p. 252°C (H₂O). Anal. $C_9H_6N_2O_3S$; C,H. 1H NMR (DMSO- d_6): δ 7.28 (H-4', dd), 7.90 (H-3', dd, $J_{3,4}$ 3.90 Hz, $J_{3,5}$ 1.95 Hz), 8.15 (H-5', dd, $J_{4,5}$ 4.88, $J_{3,5}$ 1.95 Hz), 8.85 (2H, H-4,6). MS: 206 (83, M), 205 (8), 178 (15), 150 (11), 136 (20), 111 (100).

General procedure for the preparation of 5-aryoyl-1-benzyl-2(1H)-pyrimidinones 9. Benzyl bromide (2 mmol) was added to a solution which was prepared from 2(1H)-pyrimidinone 8 (2 mmol) and triethylamine (2 mmol) in dichloromethane (30 ml). The mixture was stirred at ambient temperature overnight, extracted with water (2 \times 20 ml) and the dried (MgSO₄) solution evaporated. The solid residue was purified by recrystallization.

5-Benzoyl-1-benzyl-2(1H)-pyrimidinone 9a. Yield 55%, m.p. 150°C (EtOAc). Anal. $C_{18}H_{14}N_2O_2$; C,H. 1H NMR (CDCl₃): δ 5.15 (CH₂), 7.36 (Ph), 7.4–7.7 (PhCO), 8.30 (H-6, d, $J_{4,6}$ 3.60 Hz), 9.00 (H-4, d). MS: 290 (61, M), 289 (5), 261 (5), 220 (15), 199 (12), 91 (100).

5-Anisoyl-1-benzyl-2(1H)-pyrimidinone 9b. Yield 80%, m.p. 193°C (EtOH). Anal. $C_{19}H_{16}N_2O_3$; C,H. 1H NMR (CDCl₃): δ 3.90 (MeO), 5.20 (CH₂), 7.0 and 7.7 (C₆H₄, dd), 7.40 (Ph), 8.35 (H-6, d, $J_{4,6}$ 3.60 Hz), 9.00 (H-4, d). IR (KBr): 1675 (COR) and 1635 cm⁻¹ (CO). MS: 320 (85, M), 291 (10), 257 (8), 250 (44), 229 (25), 135 (50), 91 (100).

1-Benzyl-5-(3-trifluoromethylbenzoyl)-2(1H)-pyrimidinone 9c. Yield 68%, m.p. 184°C (EtOAc). Anal. $C_{19}H_{13}F_3N_2O_2$; C,H. 1H NMR (CDCl₃): δ 5.10 (CH₂), 7.40 (Ph), 7.6–7.9 (C₆H₄), 8.36 (H-6, d, $J_{4,6}$ 3.60 Hz), 9.00 (H-4, d). MS: 358 (53, M), 329 (5), 288 (12), 246 (8), 173 (16), 91 (100).

1-Benzyl-5-(2-furoyl)-2(1H)-pyrimidinone 9d. Yield 59%, m.p. 181°C. (EtOAc). Anal. $C_{16}H_{12}N_2O_3$; C,H. 1H NMR (CDCl₃): δ 5.19 (CH₂), 6.62 (H-4', dd), 7.35 (H-3', dd, $J_{3,4}$ 3.69, $J_{3,5}$ 0.68 Hz), 7.61 (H-5', dd, $J_{4,5}$ 1.71 Hz, $J_{3,5}$ 0.68 Hz), 7.40 (Ph), 8.65 (H-6, d, $J_{4,6}$ 3.40 Hz), 9.20 (H-4). MS: 280 (49, M), 279 (3), 251 (3), 189 (16), 95 (17), 91 (100).

1-Benzyl-5-(2-thenoyl)-2(1H)-pyrimidinone 9e. Yield 55%, m.p. 202°C. (EtOH). Anal. $C_{16}H_{12}N_2O_2S$; C,H. 1H NMR (CDCl₃): δ 5.10 (CH₂), 7.16 (H-4', dd), 7.52 (H-3, dd, $J_{3,4}$ 3.96 Hz, $J_{3,5}$ 1.96 Hz), 7.73 (H-5', dd, $J_{4,5}$ 4.83, $J_{3,5}$ 1.96 Hz), 7.40 (Ph), 8.40 (H-6, d, $J_{4,6}$ 3.60 Hz), 9.10 (H-4, d). MS: 296 (54, M), 226 (10), 205 (18), 121 (7), 111 (34), 91 (100).

References

- (a) Brown, D. J. *The Pyrimidines*, Interscience, New York 1962, p. 32; *Supplement I*, 1970, p. 24; (b) Arya, V. P., David, J., Grewal, R. S., Marathe, S. B. and Patil, S. D. *Indian J. Chem. B* 15 (1977) 1129.
- Benneche, T. and Undheim, K. *Acta Chem. Scand. B* 36 (1982) 529.
- Brown, D. J. In: Boulton, A. J. and McKillop, A., eds., *Comprehensive Heterocyclic Chemistry*, Pergamon, Oxford 1984, Vol. 3, p. 57.
- Gacek, M., Undheim, K., Oftbro, R. and Laland, S. G. *FEBS. Lett.* 98 (1979) 355.
- Beak, P. and Snieckus, V. *Acc. Chem. Res.* 15 (1982) 306.
- (a) Narasimham, S. and Mali, R. S. *Synthesis* (1983) 957; (b) Gschwend, H. W. and Rodriguez, H. R. *Org. React.* 26 (1979) 1.
- Grant, A. G., Seeman, C. and Winthrop, O. S., *Can. J. Chem.* 34 (1965) 1444.
- (a) Parham, W. E. and Bradsher, C. K. *Acc. Chem. Res.* 15 (1982) 300; (b) Parham, W. E., Bradsher, C. K. and Edgar, K. J., *J. Org. Chem.* 46 (1981) 1057; (c) Parham, W. E. and Sayed, Y. A. *J. Org. Chem.* 39 (1974) 2053.
- Gacek, M., Ongstad, L. and Undheim, K. *Acta Chem. Scand. B* 33 (1979) 150.
- Fringuelli, F., Gronowitz, S., Hörnfeldt, A.-B., Johnson, I. and Taticchi, A. *Acta Chem. Scand. B* 28 (1974) 175.
- Thomas, T. J. and Tieckelman, H. J. *Heterocycl. Chem.* 1 (1964) 201.

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