# Controlled Reduction of Pyrimidin(e)-2(1*H*)-ones and -thiones with Metal Hydride Complexes. Regioselective Preparation of Dihydro- and Tetrahydro-pyrimidin-2(1*H*)-ones and the Corresponding Thiones

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1,4,6-Trisubstituted pyrimidin-2(1*H*)-ones were easily reduced with sodium borohydride to give mixtures of 3-aryl-3,4-dihydro-, 1-aryl-3,4-dihydro-, and 3,4,5,6-tetrahydro-pyrimidin-2(1*H*)-ones. The ratio of the three products was dramatically dependent on the reaction conditions and on the nature of the 4- and 6-substituents in the pyrimidine ring. The reaction with lithium aluminium hydride is also discussed.



In a previous paper, we discussed the regioselective preparation of 3,4,4,6-tetrasubstituted 3,4-dihydro- and 1,4,4,6-tetrasubstituted 3,4-dihydro-pyrimidin(e)-2(1*H*)-ones and -thiones with organometallic compounds such as Grignard and organo-lithium reagents.[1] The di- and tetra-hydropyrimidin-2(1*H*)-ones and -thiones are useful intermediates in the synthesis of diamines,[2] thiazines,[3] and pyrimidin-2(1*H*)-ones.[4] To the best of our knowledge, the reaction of pyrimidin-2(1*H*)-ones with metal hydride complexes has not previously been reported.

Herein, we describe the regioselective preparation of 3,4-dihydro- and 3,4,5,6-tetrahydro-pyrimidin-2(1*H*)-ones and the corresponding thiones by the controlled reduction of pyrimidin(e)-2(1*H*)-ones and -thiones with metal hydride complexes, such as sodium borohydride and lithium aluminium hydride, under various conditions.

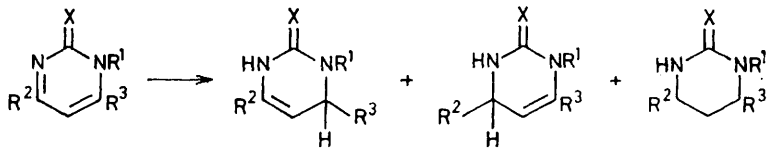
## RESULTS AND DISCUSSION

When 4,6-dimethyl-1-phenylpyrimidin-2(1*H*)-one (1a) was treated with sodium borohydride ($NaBH_4$), three products were obtained: compound A, m.p. 134—135 °C; compound B, m.p. 119—120 °C; and compound C, m.p. 178—179 °C. The microanalytical results for products A and B were consistent with their formulation as $C_{12}H_{14}N_2O$. The spectral characteristics of A and B were as follows: compound A, i.r. $\nu_{max.}$ 3 200 (N–H) and 1 660 $cm^{-1}$ (C=O) and $^1H$ n.m.r. $\delta$ 1.13 (3 H, d, $J$ 6.0 Hz) and 1.73 (3 H, s); compound B, i.r. $\nu_{max.}$ 3 220 (N–H) and 1 660 $cm^{-1}$ (C=O) and $^1H$ n.m.r. $\delta$ 1.27 (3 H, d, $J$ 6.0 Hz) and 1.52 (3 H, s). On the basis of these spectral data, compounds A and B were assumed to be structurally isomeric. Moreover comparison of the spectral characteristics with those of compounds (5) and (6)[1] allowed A and B to be assigned the structures (2a) and (2b), respectively. These structural assignments were

TABLE 1

| [(1a) : $NaBH_4$ : $B(OMe)_3$ : NaOH] | | | | Solvent [a] | Tetrahydro-(4a)/ [b] Dihydro-(2a + 3a) |
|---|---|---|---|---|---|
| 1 | 2 | 5 | 0 | A | 0.18 |
| 1 | 1 | 10 | 0 | A | 0.16 |
| 1 | 1 | 5 | 0 | A | 0.17 |
| 1 | 1 | 2 | 0 | A | 0.24 |
| 1 | 1 | 1 | 0 | A | 0.42 |
| 1 | 1 | 0 | 0 | B | 1.44 |
| 1 | 1 | 0 | 0.5 | B | 3.14 |
| 1 | 1 | 0 | 1 | B | 4.55 |
| 1 | 1 | 0 | 2 | B | 4.76 |
| 1 | 1 | 0 | 5 | B | 5.56 |
| 1 | 1 | 0 | 10 | B | 7.69 |

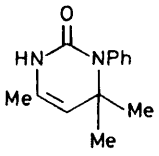
[a] A = tetrahydrofuran; B = methanol. [b] Stirring for 4 h at room temperature. Determined by l.p.c.



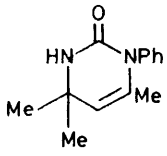
(1) (2) (3) (4)

| | X | $R^1$ | $R^2$ | $R^3$ |
|---|---|---|---|---|
| a; | O | Ph | Me | Me |
| b; | S | Ph | Me | Me |
| c; | O | Ph | Ph | Me |
| d; | O | Ph | Me | Ph |
| e; | S | Ph | Me | Ph |
| f; | O | *p*-$MeC_6H_4$ | Me | Me |
| g; | O | *p*-$MeOC_6H_4$ | Me | Me |
| h; | O | *p*-$ClC_6H_4$ | Me | Me |
| i; | O | Ph | $Pr^n$ | Me |
| j; | O | Me | Ph | Me |
| k; | O | Me | Ph | Ph |
| l; | O | *o*-$MeC_6H_4$ | H | H |
| m; | O | Ph | H | H |
| n; | O | *p*-$MeOC_6H_4$ | H | H |
| o; | S | Ph | H | H |
| p; | O | *p*-$MeC_6H_4$ | Ph | Ph |

supported by u.v. spectral evidence. Compound C gave microanalytical results consistent with its formulation as $C_{12}H_{16}N_2O$ and showed the following spectral characteristics: i.r. $\nu_{max.}$ 3 200 (N–H) and 1 650 $cm^{-1}$ (C=O) and $^1H$ n.m.r. δ 0.93 (3 H, d, *J* 6.0 Hz) and 1.13 (3 H, d, *J* 6.0 Hz). From these results compound C was deduced to have structure (4a).




(5)




(6)

The ratio of the products (2a) : (3a) : (4a) was sensitive to the reaction conditions changing from 37 : 13 : 50 with methanol as the solvent, to 0 : 4 : 96 with ethanol. Since it is known [5] that $NaBH_4$ reacts with methanol, at an appreciable rate, to form trimethyl borate, but is fairly stable in ethanol, and that formation of compound (4a) was inhibited in methanol, we assume that trimethyl borate inhibited the further reduction of (1a) to (4a). Further experiments also indicated that the formation of trimethyl borate from $NaBH_4$ could be retarded when sodium hydroxide was added to the methanol. Therefore, the addition of trimethyl borate or sodium hydroxide changed the ratio (4a)/[(2a) + (3a)], and the results are listed in Table 1. Tetrahydrofuran was used as a solvent in order to suppress the decomposition of $NaBH_4$. The yields of compounds (2a) and (3a) increased with an increase of trimethyl borate and decreased with an increase of sodium hydroxide.

TABLE 2

| Compound | Method [a] | Products | Yield (%) [b] (2) | (3) | (4) |
|---|---|---|---|---|---|
| (1a) | A | (2a) | 90 | 0 | 0 |
| (1a) | B | (4a) | 0 | 0 | 91 |
| (1a) | C | (3a) and (4a) | 0 | 31 | 52 |
| (1a) | D | (2a) and (3a) | 28 | 65 | 0 [c] |
| (1b) | A | (2b) | 85 | 0 | 0 |
| (1b) | B | (4b) | 0 | 0 | 84 |
| (1b) | C | (2b) and (4b) | 0 | 30 | 45 |
| (1b) | D | (2b) and (3b) | 45 | 45 | 0 [c] |
| (1c) | D | (2c) | 85 | 0 | 0 |
| (1c) | E | (2c) | 79 | 0 | 0 |
| (1d) | D | (3d) | 0 | 71 | 0 |
| (1d) | E | (2d) and (3d) | 19 | 77 | 0 [c] |
| (1e) | D | (3e) | 0 | 90 | 0 |
| (1e) | E | (2e) and (3e) | 57 | 38 | 0 [c] |
| (1a) | F | (4a) | 0 | 0 | 86 |
| (1b) | F | (4b) | 0 | 0 | 85 |
| (1c) | F | (4c) | 0 | 0 | 83 |
| (1f) | F | (4f) | 0 | 0 | 95 |
| (1g) | F | (4g) | 0 | 0 | 94 |
| (1h) | F | (4h) | 0 | 0 | 94 |
| (1i) | F | (4i) | 0 | 0 | 92 |
| (1j) | F | (4j) | 0 | 0 | 96 |
| (1k) | F | (4k) | 0 | 0 | 93 |
| (1l) | F | (4l) | 0 | 0 | 87 |
| (1e) | F | (3e) and (4e) | 0 | 80 | 8 |
| (1m) | F | (3m) and (4m) | 0 | 26 | 48 |
| (1n) | F | (3n) and (4n) | 0 | 19 | 74 |
| (1o) | F | (3o) and (4o) | 0 | 68 | 23 |
| (1p) | F | (3p) and (4p) | 0 | 34 | 55 |

[a] See Experimental section. [b] Isolated yield. [c] Determined by $^1H$ n.m.r. spectroscopy

The reaction of the thione (1b) with $NaBH_4$ was carried out in the same manner described above; the results of these and similar experiments are given in Table 2. The ketone (1c) was reduced with $NaBH_4$ or lithium aluminium hydride ($LiAlH_4$) to afford only compound (2c). However, the ketone (1d) and the thione (1e) reacted with $LiAlH_4$ to give exclusively the ketone (3d) and the thione (3e), respectively (see Table 2).

Since Marshall and Johnson [6] and Gribble *et al.*[7] have reported that enamines can be reduced by $NaBH_4$ in acetic acid, we examined the behaviour of the pyrimidin(e)-2(1*H*)-ones and -thiones with $NaBH_4$ in acetic acid. The compounds gave either 3,4,5,6-tetrahydro-derivatives (4) exclusively or mixtures of the dihydro- and tetrahydro-derivatives (3) and (4) (see Table 2). There is no simple correlation between the results and the steric effects of substituents at the 1-, 4-, and 6-positions in the pyrimidine ring.

It is concluded that the regioselective preparation of 3,4-dihydro- and 3,4,5,6-tetrahydro-pyrimidin(e)-2(1*H*)-ones and -thiones is achieved by the controlled reduction of the corresponding pyrimidin(e)-2(1*H*)-ones and -thiones using $NaBH_4$ and $LiAlH_4$ under a variety of conditions.

## EXPERIMENTAL

I.r. and u.v. spectra were obtained on a Jasco ITA-1 spectrophotometer and Shimadzu UV-365 UV-VIS-NIR spectrophotometer, respectively. $^1H$ N.m.r. spectra were recorded on a Hitachi R-20 spectrometer, using tetramethylsilane as an internal standard. Product ratios were determined on a Jasco FAMILIC-100 micro-h.p.l.c. instrument. The crude products were purified by recrystallization or column chromatography on silica gel with chloroform–acetone–ethanol (50 : 5 : 1) or (25 : 5 : 1) for the pyrimidin-2(1*H*)-ones, and with chloroform–benzene–ethyl acetate (4 : 4 : 1) for the pyrimidine-2(1*H*)-thiones. Yields are given in Table 2.

*Reaction of Pyrimidin(e)-2(1H)-ones and -thiones with* $NaBH_4$ *or* $LiAlH_4$.—(a) *Method A*. To a solution of the pyrimidin(e)-2(1*H*)-one (1a) or -thione (1b) (2 mmol) and trimethyl borate (6 mmol) in ethanol (20 ml) on an ice–water bath was added $NaBH_4$ (4 mmol) and the mixture was then stirred for 2 h at room temperature. The reaction mixture was diluted with water, extracted with dichloromethane, and dried over anhydrous magnesium sulphate to give, respectively, 3,4-*dihydro*-4,6-*dimethyl*-3-*phenylpyrimidin*-2(1H)-*one* (2a), m.p. 134—135 °C (from benzene–hexane); $\nu_{max.}$ (KBr) 3 200, 2 960, 1 700, 1 660, 760, and 690 $cm^{-1}$; $\lambda_{max.}$ (EtOH) 209 nm (ε 12600); δ($CDCl_3$) 1.13 (3 H, d, *J* 6.0 Hz), 1.73 (3 H, s), 4.2—4.7 (2 H, m), and 7.2—7.5 (5 H, m) (Found: C, 71.4; H, 6.9; N, 13.65. $C_{12}H_{14}N_2O$ requires C, 71.26; H, 6.97; N, 13.85%) and 3,4-*dihydro*-4,6-*dimethyl*-3-*phenylpyrimidine*-2(1H)-*thione* (2b), m.p. 119—120 °C (from benzene–hexane); $\nu_{max.}$ (KBr) 3 200, 1 705, 1 280, 765, and 700 $cm^{-1}$; δ($CDCl_3$) 1.18 (3 H, d, *J* 6.0 Hz), 1.77 (3 H, s), 4.1—4.4 (1 H, m), 4.6—4.8 (1 H, m), 7.2—7.5 (5 H, m), and 8.63 (1 H, br s) (Found: C, 66.4; H, 6.35; N, 12.55. $C_{12}H_{14}N_2S$ requires C, 66.01; H, 6.46; N, 12.83%).

(*b*) *Method B*. To a solution of the pyrimidin(e)-2-(1*H*)-one (1a) or -thione (1b) (1 mmol) and sodium hydroxide (5 mmol) in methanol (20 ml) was added $NaBH_4$ (10 mmol) and the mixture was stirred overnight at room temperature

to give, respectively, 3,4,5,6-*tetrahydro*-4,6-*dimethyl*-1-*phenylpyrimidin*-2(1H)-*one* (4a), m.p. 178—179 °C (from benzene); $\nu_{max.}$ (KBr) 3 200, 3 040, 2 960, 1 650, 760, and 680 cm$^{-1}$; $\lambda_{max.}$ (EtOH) 209 (ε 6 000) and 229 nm (3900); δ($CDCl_3$) 0.93 (3 H, d, *J* 6.0 Hz), 1.13 (3 H, d, *J* 6.0 Hz), 1.4—2.1 (2 H, m), 3.3—4.1 (2 H, m), 5.53 (1 H, br s), and 7.2—7.5 (5 H, m) (Found: C, 70.9; H, 7.9; N, 13.6. $C_{12}H_{16}N_2O$ requires C, 70.55; H, 7.89; N, 13.71%) and 3,4,5,6-*tetrahydro*-4,6-*dimethyl*-1-*phenylpyrimidine*-2(1H)-*thione* (4b), m.p. 175—176 °C (from ethyl acetate); $\nu_{max.}$ (KBr) 3 200, 1 520, 1 240, 760, and 680 cm$^{-1}$; δ($CDCl_3$) 0.93 (3 H, d, *J* 6.0 Hz), 1.23 (3 H, d, *J* 6.0 Hz), 1.5—2.3 (2 H, m), 3.3—4.2 (2 H, m), and 7.0—7.6 (5 H, m) (Found: C, 65.65; H, 7.25; N, 12.5. $C_{12}H_{16}N_2S$ requires C, 65.41; H, 7.31; N, 12.71%).

(*c*) *Method C.* To a solution of the pyrimidin(e)-2(1*H*)-one (1a) or -thione (1b) (2 mmol) in dry ether (20 ml) was added $LiAlH_4$ (2 mmol) under an argon atmosphere and the mixture was stirred for 2 h at room temperature. The reaction mixture was diluted with water and extracted with dichloromethane, and the organic layer was concentrated. The residue was treated with $NaBH_4$ as in Method B. Compound (1a) gave compound (4a) and 3,4-*dihydro*-4,6-*dimethyl*-1-*phenylpyrimidin*-2(1H)-*one* (3a), m.p. 119—120 °C (from benzene–hexane); $\nu_{max.}$ (KBr) 3 220, 1 695, 1 660, 760, and 690 cm$^{-1}$; $\lambda_{max.}$ (EtOH) 220 (ε 21 800) and 254 nm (20 000); δ($CDCl_3$) 1.27 (3 H, d, *J* 6.0 Hz), 1.52 (3 H, s), 4.1—4.3 (1 H, m), 4.6—4.8 (1 H, m), 5.90 (1 H, br s), and 7.2—7.6 (5 H, m) (Found: C, 71.15; H, 6.95; N, 13.85. $C_{12}H_{14}N_2O$ requires C, 71.26; H, 6.97; N, 13.85%).

Compound (1b) gave compound (4b) and 3,4-*dihydro*-4,6-*dimethyl*-1-*phenylpyrimidine*-2(1H)-*thiones* (3b), m.p. 140.5 °C (decomp.) (from ethyl acetate); $\nu_{max.}$ (KBr) 3 200, 1 680, 1 530, 1 220, 760, and 690 cm$^{-1}$; δ($CDCl_3$) 1.30 (3 H, d, *J* 6.0 Hz), 1.48 (3 H, s), 4.1—4.3 (1 H, m), 4.8—5.0 (1 H, m), 7.2—7.5 (5 H, m), and 7.90 (1 H, br s) (Found: C, 65.8; H, 6.4; N, 12.8. $C_{12}H_{14}N_2S$ requires C, 66.01; H, 6.46; N, 12.83%).

(d) *Method D.* To a solution of the pyrimidin(e)-2(1*H*)-one [(1c) or (1d)] or -thione (1e) (2 mmol) in dry ether (15 ml) was added, slowly, $LiAlH_4$ (1 mmol) under an argon atmosphere, and the mixture was stirred for 3 h at room temperature to give, respectively, 3,4-*dihydro*-4-*methyl*-3,6-*diphenylpyrimidin*-2(1H)-*one* (2c), m.p. 179—180 °C (from benzene–hexane); $\nu_{max.}$ (KBr) 3 200, 3 080, 2 960, 1 655, 1 285, and 700 cm$^{-1}$; δ($CDCl_3$) 1.25 (3 H, d, *J* 6.0 Hz), 4.4—4.6 (1 H, m), 5.0—5.2 (1 H, m), and 7.2—7.5 (10 H, m) (Found: C, 77.1; H, 6.05; N, 10.4. $C_{17}H_{16}N_2O$ requires C, 77.24; H, 6.10; N, 10.59%), 3,4-*dihydro*-4-*methyl*-1,6-*diphenylpyrimidin*-2(1H)-*one* (3d), m.p. 184—185 °C (from ethyl acetate); $\nu_{max.}$ (KBr) 3 240, 1 685, 1 655, 1 410, 755, and 700 cm$^{-1}$; δ($CDCl_3$) 1.37 (3 H, d, *J* 6.0 Hz), 4.1—4.5 (1 H, m), 5.0—5.2 (1 H, dd, *J* 4.0 and 2.0 Hz), 5.67 (1 H, br s), and 7.1—7.3 (10 H, m) (Found: C, 77.25; H, 6.05; N, 10.65. $C_{17}H_{16}N_2O$ requires C, 77.24; H, 6.10; N, 10.59%), and 3,4-*dihydro*-4-*methyl*-1,6-*diphenylpyrimidine*-2(1H)-*thione* (3e), m.p. 162 °C (decomp.) (from ethyl acetate); $\nu_{max.}$ (KBr) 3 200, 1 680, 1 530, 1 205, 760, and 690 cm$^{-1}$; δ($CDCl_3$) 1.42 (3 H, d, *J* 6.0 Hz), 4.1—4.6 (1 H, m), 5.0—5.2 (1 H, dd, *J* 4.0 and 2.0 Hz), 7.1—7.3 (10 H, m), and 8.0 (1 H, br s) (Found: C, 72.75; H, 5.7; N, 9.9. $C_{17}H_{16}N_2S$ requires C, 72.82; H, 5.75; N, 9.99%).

Also using Method D, (1a) gave (2a) and (3a), and (1b) gave (2b) and (3b).

(e) *Method E.* To a solution of the pyrimidin(e)-2(1*H*)-one (1d) or -thione (1e) (2 mmol) in methanol (20 ml) was added $NaBH_4$ (2 mmol), and the mixture was stirred for 3 h at room temperature. Compound (1d) gave compound (3d) and 3,4-*dihydro*-6-*methyl*-3,4-*diphenylpyrimidin*-2(1H)-*one* (2d),* m.p. 182—186 °C (from ethyl acetate); δ($CDCl_3$) 1.77 (3 H, s), 4.6—4.8 (1 H, m), 5.0—5.3 (1 H, m), and 7.0—7.3 (10 H, m) {Found [for a mixture of (4a) and (4b)]: C, 77.15; H, 6.1; N, 10.65. $C_{17}H_{16}N_2O$ requires C, 77.25; H, 6.10; N, 10.59%}.

Compound (1e) gave compound (3e) and 3,4-*dihydro*-6-*methyl*-3,4-*diphenylpyrimidine*-2(1H)-*thione* (2e),* m.p. 207—212 °C (from ethyl acetate); δ($CDCl_3$) 1.73 (3 H, s), 3.8—4.3 (1 H, m), 4.9—5.2 (1 H, m), and 6.8—7.3 (10 H, m) {Found [for a mixture of (5a) and (5b)]: C, 73.15; H, 5.75; N, 10.1. $C_{17}H_{16}N_2S$ requires C, 72.82; H, 5.75; N, 9.99%}.

Also using Method E compound (1c) gave compound (2c).

(f) *Method F.* $NaBH_4$ (10 mmol) was added slowly to a solution of the pyrimidin(e)-2(1*H*)-one [(1c), (1f)—(1n), and (1p)] or -thione [(1e) and (1o)] (1 mmol) in acetic acid (8 ml) and the mixture was stirred for 1 h at room temperature. The reaction mixture was neutralized cautiously with aqueous sodium hydroxide, on an ice–water bath, and then extracted with dichloromethane and dried over anhydrous magnesium sulphate. Compound (1c) gave 3,4,5,6-*tetrahydro*-6-*methyl*-1,4-*diphenylpyrimidin*-2(1H)-*one* (4c), m.p. 189 °C (from benzene–hexane); $\nu_{max.}$ (KBr) 3 220, 3 060, 1 650, 1 430, 750, and 690 cm$^{-1}$; δ($CDCl_3$) 0.95 (3 H, d, *J* 6.0 Hz), 1.7—2.5 (2 H, m), 3.8—4.3 (1 H, m), 4.5—4.8 (1 H, dd, *J* 10.5 and 4.0 Hz), 5.17 (1 H, br s), and 7.2—7.6 (10 H, m) (Found: C, 76.45; H, 6.75; N, 10.5. $C_{17}H_{18}N_2O$ requires C, 76.66; H, 6.81; N, 10.51%).

Compound (1e) gave compound (3e) and 3,4,5,6-*tetrahydro*-4-*methyl*-1,6-*diphenylpyrimidine*-2(1H)-*thione* (4e), m.p. 204—205 °C (from ethyl acetate); $\nu_{max.}$ (KBr) 3 200, 3 030, 1 600, 1 260, 760, and 690 cm$^{-1}$; δ($CDCl_3$) 1.23 (3 H, d, *J* 6.0 Hz), 2.0—2.5 (2 H, m), 3.6—4.1 (1 H, m), 4.8—5.1 (1 H, dd, *J* 9.5 and 6.0 Hz), and 7.0—7.5 (10 H, m) (Found: C, 72.45; H, 6.4; N, 9.9. $C_{17}H_{18}N_2S$ requires C, 72.30; H, 6.42; N, 9.91%).

Compound (1f) gave 3,4,5,6-*tetrahydro*-4,6-*dimethyl*-(p-*tolyl*)*pyrimidin*-2(1H)-*one* (4f), m.p. 220—221 °C (from benzene); $\nu_{max.}$ (KBr) 3 210, 2 960, 1 660, 1 600, and 800 cm$^{-1}$; δ($CDCl_3$) 0.96 (3 H, d, *J* 6.0 Hz), 1.20 (3 H, d, *J* 6.0 Hz), 1.7—2.1 (2 H, m), 2.35 (3 H, s), 3.4—4.1 (2 H, m), 4.8 (1 H, br s), and 7.0—7.3 (4 H, m) (Found: C, 71.5; H, 8.25; N, 12.8. $C_{13}H_{18}N_2O$ requires C, 71.52; H, 8.31; N, 12.83%)

Compound (1g) gave 3,4,5,6-*tetrahydro*-1-(p-*methoxyphenyl*)-4,6-*dimethylpyrimidin*-2(1H)-*one* (4g), m.p. 218—219 °C (from benzene); $\nu_{max.}$ (KBr) 3 230, 2 970, 1 660, 820, and 740 cm$^{-1}$; δ($CDCl_3$) 0.93 (3 H, d, *J* 6.0 Hz), 1.18 (3 H, d, *J* 6.0 Hz), 1.6—2.1 (2 H, m), 3.79 (3 H, s), 3.5—4.2 (2 H, m), and 6.8—7.4 (4 H, m) (Found: C, 66.7; H, 7.75; N, 11.95. $C_{13}H_{18}N_2O_2$ requires C, 66.64; H, 7.74; N, 11.95%).

Compound (1h) gave 1-(p-*chlorophenyl*)-3,4,5,6-*tetrahydro*-4,6-*dimethylpyrimidin*-2(1H)-*one* (4h), m.p. 240—241 °C (from benzene); $\nu_{max.}$ (KBr) 3 240, 2 990, 1 660, 820, and 750 cm$^{-1}$; δ($CDCl_3$) 0.97 (3 H, d, *J* 6.0 Hz), 1.18 (3 H, d, *J* 6.0 Hz), 1.4—2.1 (2 H, m), 3.4—4.1 (2 H, m), 5.0 (1 H, br s), and 7.0—7.5 (4 H, m) (Found: C, 60.4; H, 6.3; N, 11.75. $C_{12}H_{15}ClN_2O$ requires C, 60.37; H, 6.33; N, 11.73%).

Compound (1i) gave 3,4,5,6-*tetrahydro*-6-*methyl*-1-*phenyl*-4-*n*-*propylpyrimidin*-2(1H)-*one* (4i), m.p. 166—167 °C (from hexane); $\nu_{max.}$ (KBr) 3 200, 1 650, 760, and 680 cm$^{-1}$;

* Attempts to separate the mixture by column chromatography or fractional recrystallization were unsuccessful.

δ($CDCl_3$) 0.93 (3 H, d, *J* 6.0 Hz), 0.95 (3 H, t, *J* 6.0 Hz), 1.2—2.1 (2 H, m), 3.5—4.2 (2 H, m), 4.85 (1 H, br s), and 7.1—7.4 (5 H, m) (Found: C, 72.3; H, 8.7; N, 11.95. $C_{14}H_{20}N_2O$ requires C, 72.37; H, 8.67; N, 12.05%).

Compound (1j) gave 3,4,5,6-*tetrahydro*-1,6-*dimethyl*-4-*phenylpyrimidin*-2(1H)-*one* (4j), m.p. 124—125 °C (from benzene–hexane); $\nu_{max.}$ (KBr) 3 210, 3 060, 2 960, 1 650, 745, and 690 $cm^{-1}$; δ($CDCl_3$) 1.18 (3 H, d, *J* 6.0 Hz), 1.6—2.4 (2 H, m), 2.93 (3 H, s), 3.2—3.8 (1 H, m), 4.3—4.7 (1 H, dd, *J* 10.5 and 4.0 Hz), 5.10 (1 H, br s), and 7.2—7.4 (5 H, m) (Found: C, 70.4; H, 7.85; N, 13.6. $C_{12}H_{16}N_2O$ requires C, 70.55; H, 7.89; N, 13.17%).

Compound (1k) gave 3,4,5,6-*tetrahydro*-1-*methyl*-4,6-*diphenylpyrimidin*-2(1H)-*one* (4k), m.p. 219 °C (from benzene); $\nu_{max.}$ (KBr) 3 200, 3 070, 2 960, 1 640, 760, and 700 $cm^{-1}$; δ($CDCl_3$) 1.9—2.4 (2 H, m), 2.73 (3 H, s), 4.3—4.8 (2 H, m), 4.97 (1 H, br s), and 7.3—7.5 (10 H, m) (Found: C, 76.45; H, 6.7; N, 10.25. $C_{17}H_{18}N_2O$ requires C, 76.66; H, 6.81; N, 10.51%).

Compound (1l) gave 3,4,5,6-*tetrahydro*-1-(o-*tolyl*)*pyrimidin*-2(1H)-*one* (4l), m.p. 193—194 °C (from ethyl acetate); $\nu_{max.}$ (KBr) 3 220, 3 060, 1 650, 1 500, 755, and 720 $cm^{-1}$; δ($CDCl_3$) 1.8—2.2 (2 H, m), 2.33 (3 H, s), 3.2—3.6 (4 H, m), 6.28 (1 H, br s), and 7.1—7.3 (4 H, m) (Found: C, 69.7; H, 7.45; N, 14.75. $C_{11}H_{14}N_2O$ requires C, 69.44; H, 7.41; N, 14.72%).

Compound (1m) gave 3,4-*dihydro*-1-*phenylpyrimidin*-2-(1H)-*one* (3m), m.p. 170—171 °C (from ethyl acetate); $\nu_{max.}$ (KBr) 3 240, 1 685, 1 660, 1 290, 1 140, 760, and 690 $cm^{-1}$; δ($CDCl_3$) 4.0—4.3 (2 H, m), 4.7—5.1 (1 H, m), 6.07 (1 H, br s), 6.2—6.5 (1 H, dt, *J* 8.0 and 1.5 Hz), and 7.1—7.4 (5 H, m) (Found: C, 68.7; H, 5.75; N, 16.0. $C_{10}H_{10}N_2O$ requires C, 68.94; H, 5.78; N, 16.08%), and 3,4,5,6-*tetrahydro*-1-*phenylpyrimidin*-2(1H)-*one* (4m), m.p. 205 °C (from ethyl acetate); $\nu_{max.}$ (KBr) 3 220, 3 060, 1 650, 760, and 695 $cm^{-1}$; δ($CDCl_3$) 1.8—2.3 (2 H, m), 3.2—3.5 (2 H, m), 3.5—3.9 (2 H, m), 6.20 (1 H, br s), and 7.2—7.6 (5 H, m) (Found: C, 68.15; H, 6.8; N, 15.85. $C_{10}H_{12}N_2O$ requires C, 68.15; H, 6.86; N, 15.89%).

Compound (1n) gave 3,4-*dihydro*-1-(p-*methoxyphenyl*)-*pyrimidin*-2(1H)-*one* (3n), m.p. 178—180 °C (from ethyl acetate–hexane); $\nu_{max.}$ (KBr) 3 240, 2 960, 1 695, 1 670, 1 440, 1 245, and 825 $cm^{-1}$; δ($CDCl_3$) 3.82 (3 H, s), 4.1—4.3 (2 H, m), 4.7—5.1 (1 H, m), 5.40 (1 H, br s), 6.1—6.4 (1 H, dt, *J* 8.0 and 1.5 Hz), 6.8—7.1 (2 H, m), and 7.1—7.4 (2 H, m) (Found: C, 64.5; H, 5.9; N, 13.65. $C_{11}H_{12}N_2O_2$ requires C, 64.69; H, 5.92; N, 13.71%) and 3,4,5,6-*tetrahydro*-1-(p-*methoxyphenyl*)*pyrimidin*-2(1H)-*one* (4n), m.p. 206—207 °C (from ethyl acetate); $\nu_{max.}$ (KBr) 3 220, 3 070, 2 950, 1 660, 1 250, and 760 $cm^{-1}$; δ($CDCl_3$) 1.9—2.3 (2 H, m), 3.2—3.8 (4 H, m), 3.78 (3 H, s), 5.90 (1 H, br s), 6.8—7.0 (2 H, m), and 7.2—7.4 (2 H, m) (Found: C, 63.95; H, 6.8; N, 13.5. $C_{11}H_{14}N_2O_2$ requires C, 64.06; H, 6.84; N, 13.58%).

Compound (1o) gave 3,4-*dihydro*-1-*phenylpyrimidine*-2-(1H)-*thione* (3o), m.p. 165 °C (decomp.) (from ethyl acetate); $\nu_{max.}$ (KBr) 3 210, 1 675, 1 555, 1 270, and 695 $cm^{-1}$; δ($CDCl_3$) 4.0—4.2 (2 H, m), 4.9—5.3 (1 H, m), 6.0—6.3 (1 H, dt, *J* 8.0 and 1.5 Hz), 7.2—7.5 (5 H, m), and 7.76 (1 H, br s) (Found: C, 63.25; H, 5.2; N, 14.55. $C_{10}H_{10}N_2S$ requires C, 63.12; H, 5.29; N, 14.72%), and 3,4,5,6-*tetrahydro*-1-*phenylpyrimidine*-2(1H)-*thione* (4o), m.p. 211—212 °C (from ethyl acetate); $\nu_{max.}$ (KBr) 3 200, 1 540, 1 500, 1 195, 770, and 700 $cm^{-1}$; δ($CDCl_3$) 1.9—2.3 (2 H, m), 3.2—3.8 (4 H, m), 7.2—7.4 (5 H, m), and 7.90 (1 H, br s) (Found: C, 62.3; H, 6.25; N, 15.0. $C_{10}H_{12}N_2S$ requires C, 62.46; H, 6.29; N, 14.56%).

Compound (1p) gave 3,4-*dihydro*-4,6-*diphenyl*-1-(p-*tolyl*)-*pyrimidin*-2(1H)-*one* (3p), m.p. 154—155 °C (from ethyl acetate–hexane); $\nu_{max.}$ (KBr) 3 230, 3 080, 1 690, 750, and 700 $cm^{-1}$; δ($CDCl_3$) 2.13 (3 H, s), 5.0—5.3 (2 H, m), 6.13 (1 H, br s), and 6.9—7.5 (14 H, m) (Found: C, 80.95; H, 5.85; N, 8.25. $C_{23}H_{20}N_2O$ requires C, 81.14; H, 5.92; N, 8.22%) and 3,4,5,6-*tetrahydro*-4,6-*diphenyl*-1-(p-*tolyl*)-*pyrimidin*-2(1H)-*one* (4p), m.p. 233 °C (from ethyl acetate); $\nu_{max.}$ (KBr) 3 240, 1 660, 1 430, 765, and 750 $cm^{-1}$; δ($CDCl_3$) 2.1—2.7 (2 H, m), 2.16 (3 H, s), 4.7—5.3 (2 H, m), and 6.9—7.5 (14 H, m) (Found: C, 80.45; H, 6.35; N, 8.1. $C_{23}H_{22}N_2O$ requires C, 80.67; H, 6.47; N, 8.18%).

Also using this method, compounds (1a) and (1b) gave compounds (4a) and (4b), respectively.

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