they can now be used for the design of novel, mild phosphorylating agents, possibly of use at physiological pH.

Experimental Section[15]

Methyl Benzoylphosphonochloridate (3). To methyl hydrogen benzoylphosphonate[5] (2, 20 g, 0.1 mol) in dry dichloromethane (70 mL) was added dropwise freshly distilled thionyl chloride (11.9 g, 7.3 mL, 0.1 mol). After the reaction mixture had been stirred for 3 h at ambient temperature, the solvent was evaporated to afford 3 as an unstable oil. It was identified by its ^{31}P NMR chemical shift (δ 14.4) and the coupling of this signal with ^{1}H (q) and used immediately without further purification.

Methyl *o*-Nitrobenzyl Benzoylphosphonate (4a). To a solution of 3 (21.8 g, 0.1 mol) in dry dichloromethane (70 mL), stirred under nitrogen at 0 °C, was added dropwise a solution of *N,N*-diethylaniline (17.5 mL, 0.11 mol) and *o*-nitrobenzyl alcohol (15.3 g, 0.1 mol) in dry dichloromethane (70 mL) over a period of 30 min. After the reaction mixture had been stirred for 3 h at ambient temperature, the solvent was removed at reduced pressure and the residue was taken up in anhydrous ether. *N,N*-Diethylanilinium chloride was removed by filtration; evaporation of the ether yielded 30 g (90%) of crude 4a as an oil: δ ^{31}P ($CDCl_3$) -1.8 (sext); IR (neat) CH 3050, C=O 1656, C=C 1594, P=O 1260 cm^{-1}. This product was used immediately without further purification for the synthesis of oxime 5a, which served as a derivative for analysis.

Methyl Benzyl Benzoylphosphonate (4b). A procedure identical with that used to prepare 4a was followed (crude yield 90%): IR (neat) CH 3050, C=O 1650, C=C 1594, P=O 1270, POC 1047 cm^{-1}; δ ^{31}P ($CDCl_3$) -1.4 (sext). This product was used immediately without further purification for the synthesis of the oxime derivative 5b.

Dibenzyl Benzoylphosphonate (4c). To benzoyl chloride (14 g, 0.1 mol) cooled to 0 °C was added 35.2 g of tribenzyl phosphite[16] dropwise with stirring at such a rate that the temperature of the reaction mixture remained below 10 °C. After all of the phosphite had been added, the reaction mixture was stirred for 3 h at ambient temperature. The excess benzoyl chloride was removed by vacuum distillation (60 °C at 1 mm) to leave dibenzyl benzoylphosphonate as a crude (80%) oil: δ ^{31}P ($CDCl_3$) -1.25 (quint). Dibenzyl benzylphosphonate (20%, δ ^{31}P 16.9) was also formed from Arbusov reaction of benzoyl chloride (generated in the initial reaction) with tribenzyl phosphite. The product mixture was used without further purification for the synthesis of the oxime derivative 5c.

Dibenzyl [α-(Hydroxyimino)benzyl]phosphonate (5c). Dibenzyl benzoylphosphonate (4c, 36.6 g, 0.1 mol) was added to a solution of hydroxylamine hydrochloride (8.3 g, 0.12 mol) and dry pyridine (10.5 mL, 0.13 mol) in absolute methanol (100 mL). After the reaction mixture had been stirred for 5 h, the methanol was evaporated under reduced pressure to yield a syrup, which was taken up in 1 M HCl (50 mL). The aqueous mixture was extracted with chloroform (4 × 75 mL), and the combined extracts were washed with water (100 mL), dried over anhydrous magnesium sulfate, filtered, and evaporated. The residue was chromatographed on silica. After the elution of dibenzyl benzylphosphonate and dibenzyl phosphonate (side product obtained via C-P bond cleavage in 4c) by chloroform, the product 5c (a 8:2 mixture of *E, Z* isomers) was eluted with 5% methanol in chloroform: yield 22.5 g (60%); mp 79-80 °C; NMR ($CDCl_3$) δ ^{31}P 9.6 (*E*-5c), 5.5 (*Z*-5c); δ ^{1}H 5.05 (broad, 4 H), 7.49-7.18 (m, 15 H). Anal. Calcd for $C_{21}H_{20}NO_4P$: C, 66.14; H, 5.25. Found: C, 65.99; H, 5.31.

Methyl *o*-Nitrobenzyl [α-(Hydroxyimino)benzyl]phosphonate (5a). This compound was prepared as a *E-Z* mixture (solid) and purified as described for 5c: NMR ($CDCl_3$) δ ^{31}P 10.1 (80% *E*-5a), 6.4 (20% *Z*-5a); ^{1}H δ 3.83 and 3.82 (both d, J = 12 Hz, total 3 H), 5.55 (broad, 2 H), 7.56-7.32 (m, 9 H), 8.08 (d, J = 8.4 Hz, 1 H). Anal. Calcd for $C_{15}H_{15}N_2O_6P$: C, 51.42; H, 4.28; N, 8.0. Found: C, 51.57; H, 4.35; N, 7.91.

Methyl Benzyl [α-(Hydroxyimino)benzyl]phosphonate (5b). This compound (*E-Z* mixture, oil) was prepared and purified as described for 5c: NMR ($CDCl_3$) δ ^{31}P 10.4 (50%, *E*-5b), 6.6 (50%, *Z*-5b); ^{1}H δ 3.83 and 3.82 (both d, J = 12 Hz, total 3 H), 5.01 (broad, 2 H), 7.55-7.34 (m, 10 H). Anal. Calcd for $C_{15}H_{16}NO_4P$: C, 59.01; H, 5.24; N, 4.59. Found: C, 59.11; H, 5.23; N, 4.71.

Irradiation Experiments. Solutions of 5a or 5b (0.008 M in absolute ethanol or in dioxane containing 5 equiv of ethanol) were irradiated with a Hanovia 450-W medium-pressure lamp (nominally 254 nm) at room temperature for 5 h, in a quartz apparatus[6] described elsewhere.[7] These reactions gave ethyl methyl hydrogen phosphate (7, δ ^{31}P 0.25) in over 90% yield (determined by ^{31}P NMR). Similarly, irradiation of 5c gave ethyl dihydrogen phosphate (8, δ ^{31}P 0.12) in nearly quantitative yields. In all experiments the formation of benzonitrile was observed by GC and IR.

Gas Chromatography-Mass Spectrometry of the Irradiation Products. Samples obtained from the two irradiation experiments were subjected to methylation with diazomethane (generated from Diazald). The products had the same ^{31}P NMR spectrum (δ +1.25, $CDCl_3$) and GC retention time (4.05 min) on a 25 m × 0.21 mm i.d. column of DB-5 (temperature program 60 °C per min for 1 min, then 15 °C per min, injector 260 °C). By using an atomic emission GC detector set at the frequency for phosphorus (186 nm), it was shown that the only significant phosphorus-containing product was that with retention time 4.05 min. The MS detector confirmed that this product (9) was identical whether originated from either 5a or 5c. MS: $M^+ - 1$ (2.4) m/z 127 (100, $M^+ - C_2H_3$), 110 (19.2), 96 (24.2), 79 (15.5).

Acknowledgment. This research was supported, in part, by Grant No. 86-00021 from the United States-Israel Binational Science Foundation (B.S.F.), Jerusalem, Israel (to E.B.), and in part by the U.S. Army Research Office (to L.D.Q.). M.M. thanks B.S.F. for a travel grant, which made it possible to carry out most of this work in Amherst.

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Lithiation of Polychloropyrimidines and Dichloropyridines

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Received January 30, 1991

Lithiation of aromatic compounds is useful for synthesis of polyfunctional derivatives and heteropolycycles, and as π-deficient heterocycles the pyridines have attracted much attention. The ortho-directing efficiency of halogens in the reaction should be pointed out in particular.[2] Metalation of related pyrimidines is scarcely documented[3] with a few notable exceptions, viz. the recent regioselective lithiation of methoxypyrimidines with LTMP.[4] Under the same conditions, lithiation of 2,4-dichloropyrimidine (1a) was not regioselective as the two possible lithio derivatives were trapped in equal amounts and in low yield.[5]

We have disclosed the preparation of (α-hydroxybenzyl)pyridines and -pyrimidines via ortho-lithiation of

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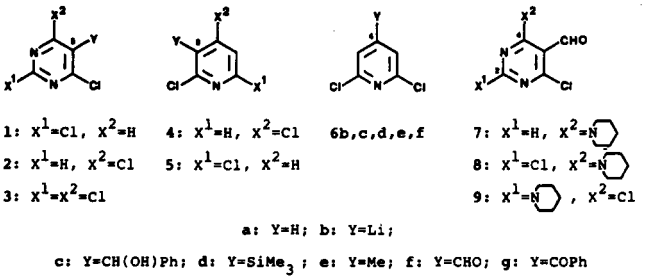

1: X^1=Cl, X^2=H 4: X^1=H, X^2=Cl 6b,c,d,e,f 7: X^1=H, X^2=N⬡
2: X^1=H, X^2=Cl 5: X^1=Cl, X^2=H 8: X^1=Cl, X^2=N⬡
3: X^1=X^2=Cl 9: X^1=N⬡, X^2=Cl

a: Y=H; b: Y=Li;

c: Y=CH(OH)Ph; d: Y=$SiMe_3$; e: Y=Me; f: Y=CHO; g: Y=COPh

4-chloropyridine and **2a** with LDA.[6] Substitution of halogen at activated ring positions with N- and O-nucleophiles allowed convenient access to polycycles with a fused pyridine ring.[7]

Our present detailed studies are on the regioselective lithiation of the polychloropyrimidines **1a**, as well as **2a** and **3a**, and the dichloropyridines **4a** and **5a** as model structures and useful synthetic precursors bearing halogens at the three activated ring positions.

Organometallics of type **b** were generated under standard conditions with LDA (1 equiv) in THF at −80 °C[8] for 30 min. Addition of substrate to metalating agent, securing thereby an excess of the latter in the reaction mixture, is essential for the lithiation of chloropyrimidines. When LDA was in deficiency the starting pyrimidines were decomposed. Quenching with electrophiles afforded substituted pyrimidines and pyridines **1–6c–f** (Tables I and II). No metalation products were formed in ether, since starting materials could be recovered quantitatively.[9]

Thus, lithiation of **1a–3a** with LDA in THF (Table I) was highly regioselective at C-5 of the pyrimidine ring as monitored by GC and ^{1}H NMR analysis of the crude reaction products. Addition or substitution reaction products were also not detectable. High yields of **2c** and **3c** vs **1c** highlight the powerful ortho-directing ability of the 1,3-dichloro substitution in **2a** and **3a**, which is in accordance with the reported stability of (2,6-dichlorophenyl)lithium[10] in the benzene series. This activating effect was confirmed in competition experiments with lithiated pyrimidines **1b–3b**. Organolithiums **1b–3b** were equally reactive, since constant product ratios, corresponding to the final yields of **1c–3c** (Table I), were found at different extents of conversion when equimolar mixtures of **1a–3a** were lithiated with LDA (1 equiv) and then competitively trapped with PhCHO (0.5 equiv). Accordingly, **1b–3b** are formed by independent metalation of **1a–3a**, which is the product ratio determining step. With *n*-BuLi, **3a** gave **3c** also in a clean reaction in high yield. Formylation of **2b** and **3b** with *N*-formylpiperidine was followed by nucleophilic substitution at C-4 and C-2, yielding **7** and **8/9**, respectively, as the only reaction products.

Lithiation of pyridine **4a** bearing the same ortho-directing functionality was also highly regioselective at C-3; **4c–f** were the only products even with a 2-fold excess of LDA or with *n*-BuLi (Table I). Contrary to monosubstituted pyridine analogues,[2] nucleophilic addition to dichloropyridines was not observed.

When **5a** was lithiated with LDA under standard conditions, 3-substituted pyridines **5d–f** were obtained as the major products on quenching with Me_3SiCl, MeI, or *N*-formylpiperidine, respectively (Table II). The minor products were the 4-substituted pyridines **6d–f** formed via the C-4 lithiated intermediate **6b**.[11] A different selectivity was found on quenching with PhCHO, since a 2:1 mixture of the two isomeric alcohols **5c** and **6c** was obtained.

To interpret this unusual selectivity, we first established that **5b** and **6b**, generated with LDA under standard conditions, were about equally reactive on competitive quenching with PhCHO. Consequently, the product ratio is dependent exclusively on the metalation step, lithiation time, and amount and nature of lithiating agent. Evaluating these parameters in the reaction with PhCHO, we find that the lithiated species generated with LDA show an equilibrium shift from **6b** to **5b**, whereas with *n*-BuLi as the lithiating agent no equilibration occurs. Thus, at 150-min lithiation time with LDA an equilibrium ratio of 98:2 was reached, resulting in the selective formation of **5c** in 92% yield. With excess LDA or with *n*-BuLi as a stronger base **6c** predominated, but no dimetalation products were detectable. The highest selectivity of 85:15 for **6c** (76% yield) was obtained by lithiation with *s*-BuLi. Hence, an "acid–base" (inductive) mechanism[12] may be suggested for the priority lithiation at C-4.

The same selectivity for the formation of **6c–e** was found on reaction of **5a** with *n*-BuLi under standard conditions (Table II), indicating no equilibrium shift upon trapping with PhCHO, Me_3SiCl, or MeI. Quenching with *N*-formylpiperidine, however, yielded **5f** predominantly due to equilibration of **6b** to **5b**.

These results are consistent with an initial protophilic attack on H-4 leading to intermediate **6b**, which equilibrates to the more stable **5b**, probably via transmetalation

Table I. Lithiation of Polychloropyrimidines 1a–3a and 2,4-Dichloropyridine 4a[a]

electrophile	metal. agent	product	GC yields of products[b] (%) 1	2	3	4
PhCHO	LDA	c	39 (38)	84 (60)	91 (84)	90 (85)
	n-BuLi		0	27	90 (82)	88 (74)
Me_3SiCl	LDA	d	8 (6)	68 (44)	72 (67)	71 (70)
NCHO	LDA	f		*c*	*d*	72 (55)

[a] Standard conditions, see text. [b] Preparative yields of chromatographed and crystallized products in parentheses. [c] The C-4 monosubstituted product **7** was obtained in 71% yield. [d] A 2:1 mixture of isomers **8** and **9** was obtained in 40% yield as a result of concomitant monosubstitution at C-4 or C-2.

Table II. Lithiation of 2,6-Dichloropyridine 5a[a]

electrophile	metal. agent	product	product ratio[b] 5:6	GC yields of products[c] (%) 5	6
PhCHO	LDA	c	64:36	61	35
	n-BuLi		26:74	21	60
Me_3SiCl	LDA	d	90:10	76 (72)	8
	n-BuLi		26:74	10	64 (60)
MeI	LDA	e	91:9	78 (76)	8
	n-BuLi		28:72	20	71 (64)
NCHO	LDA	f	91:9	60 (56)	6
	n-BuLi		80:20	50	12

[a] Standard conditions, see text. [b] Determined by both GC and ^{1}H NMR. [c] Preparative yields of chromatographed and crystallized products in parentheses.

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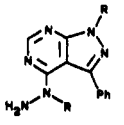
Table III. Physical and Spectroscopic Data of Products[a]

product	mp (°C) (solvent)	molecular formula[b] (MW)	MS (70 eV) *m/e* (%)	^{1}H NMR (solvent) δ
1c	oil[c]	$C_{11}H_8Cl_2N_2O$ (255.1)	254 (7) 79 (100)	($CDCl_3$) 2.91 (s, 1 H), 6.04 (s, 1 H), 7.36 (s, 5 H), 8.87 (s, 1 H)
3c	101–102 (hexane)	$C_{11}H_7Cl_3N_2O$ (289.5)	288 (4) 79 (100)	($CDCl_3$) 3.05 (d, 1 H, *J* = 9.0 Hz), 6.54 (d, 1 H, *J* = 9.0 Hz), 7.3 (m, 5 H)
4c	125–126 (ether/hexane)	$C_{12}H_9Cl_2NO$ (254.1)	253 (6) 79 (100)	($CDCl_3$) 3.43 (d, 1 H, *J* = 10 Hz), 6.62 (d, 1 H, *J* = 10 Hz), 7.3 (m, 6 H), 8.25 (d, 1 H, *J* = 5.2 Hz)
5c	79–80 (ether/hexane)	$C_{12}H_9Cl_2NO$ (254.1)	253 (5) 79 (100)	($CDCl_3$) 2.59 (d, 1 H, *J* = 3.0 Hz), 6.08 (d, 1 H, *J* = 3.0 Hz), 7.27 (d, 1 H, *J* = 7.7 Hz), 7.33 (m, 5 H), 7.99 (d, 1 H, *J* = 7.7 Hz)
6c	oil	$C_{12}H_9Cl_2NO$ (254.1)	253 (6) 79 (100)	($CDCl_3$) 2.95 (d, 1 H, *J* = 3.0 Hz), 5.71 (d, 1 H, *J* = 3.0 Hz), 7.3 (m, 7 H)
1d	34–35 (hexane)	$C_7H_{10}Cl_2N_2Si$ (221.2)	221 (0.1) 205 (12) 93 (100)	($CDCl_3$) 0.41 (s, 9 H), 8.49 (s, 1 H)
2d	48–49.5 (hexane)	$C_7H_{10}Cl_2N_2Si$ (221.2)	221 (0.2) 205 (12) 93 (100)	($CDCl_3$) 0.51 (s, 9 H), 8.67 (s, 1 H)
3d	41–42 (hexane)	$C_7H_9Cl_3N_2Si$ (255.6)	256 (0.1) 241 (8) 93 (100)	($CDCl_3$) 0.51 (s)
4d	oil	$C_8H_{11}Cl_2NSi$ (220.2)	219 (0.2) 204 (100)	($CDCl_3$) 0.50 (s, 9 H), 7.18 (d, 1 H, *J* = 5.2 Hz), 8.18 (d, 1 H, *J* = 5.2 Hz)
5d	oil	$C_8H_{11}Cl_2NSi$ (220.2)	219 (1) 204 (8) 73 (100)	($CDCl_3$) 0.35 (s, 9 H), 7.22 (d, 1 H, *J* = 7.5 Hz), 7.69 (d, 1 H, *J* = 7.5 Hz)
6d	83–85 (hexane)	$C_8H_{11}Cl_2NSi$ (220.2)	219 (1) 73 (100)	($CDCl_3$) 0.29 (s, 9 H), 7.29 (s, 2 H)
6e	oil	$C_6H_5Cl_2N$ (162.2)	162 (100)	($CDCl_3$) 2.32 (s, 3 H), 7.06 (s, 2 H)
4f	70–71 (hexane)	$C_6H_3Cl_2NO$ (176.0)	176 (10) 175 (100)	($CDCl_3$) 7.40 (d, 1 H, *J* = 5.4 Hz), 8.40 (d, 1 H, *J* = 5.4 Hz), 10.45 (s, 1 H)
6f	oil	$C_6H_3Cl_2NO$ (176.0)	176 (100)	($CDCl_3$) 7.66 (s, 2 H), 10.00 (s, 1 H)
3g	154–155 (hexane)	$C_{11}H_5Cl_3N_2O$ (287.5)	287 (100)	($CDCl_3$) 7.54 (t, 2 H, *J* = 7.8 Hz), 7.71 (t, 1 H, *J* = 7.0 Hz), 7.81 (d, 2 H)
4g	79–80 (ether)	$C_{12}H_7Cl_2NO$ (252.1)	252 (100)	($CDCl_3$) 7.39 (d, 1 H, *J* = 5.4 Hz), 7.50 (t, 2 H, *J* = 7.5 Hz), 7.65 (t, 1 H), 7.81 (d, 2 H, *J* = 7.0 Hz), 8.41 (d, 1 H, *J* = 5.4 Hz)
7	81.5–82 (hexane)	$C_{10}H_{12}ClN_3O$ (225.7)	225 (100)	($CDCl_3$) 1.8 (m, 6 H), 3.7 (m, 4 H), 8.27 (s, 1 H), 10.18 (s, 1 H)
8	oil	$C_{10}H_{11}Cl_2N_3O$ (260.1)	260 (100)	($CDCl_3$) 1.7 (m, 6 H), 3.6 (m, 4 H), 10.03 (s, 1 H)
9	oil	$C_{10}H_{11}Cl_2N_3O$ (260.1)	260 (100)	($CDCl_3$) 1.7 (m, 6 H), 3.8 (m, 4 H), 10.08 (s, 1 H)
10a	216–218 (methanol)	$C_{11}H_{10}N_6$ (226.2)	227 (100)[d]	(DMSO-d_6) 8.0 (m, 3 H), 8.26 (s, 1 H), 8.34 (d, 2 H, *J* = 7.0 Hz), 12.21 (s, 1 H)[e]
10b	oil	$C_{13}H_{14}N_6$ (254.3)	255 (100)[d]	(DMSO-d_6) 2.93 (s, 3 H), 4.06 (s, 3 H), 7.51 (m, 3 H), 7.63 (m, 2 H), 8.59 (s, 1 H)[e]
12	192–193 (ether)	$C_{17}H_{11}N_4Cl$ (306.8)		(DMSO-d_6) 7.04 (t, 1 H, *J* = 4.6 Hz), 7.1 (m, 2 H), 7.25 (t, 1 H, *J* = 4.7 Hz), 7.4 (m, 3 H), 7.5 (m, 2 H), 8.53 (d, 1 H, *J* = 4.5 Hz), 9.22 (d, 1 H, *J* = 4.0 Hz)

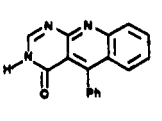
[a] Data for previously reported compounds **2c,g**,[6] **5e**,[14] **5f**,[15] **5g**,[16] and **11**[17] are available as supplementary material. [b] Satisfactory elemental analyses were obtained. [c] The product polymerized on standing at rt and was stored at −18 °C. ^{13}C NMR ($CDCl_3$) δ 70.81 (d), 126.98 (d), 128.78 (d), 128.91 (d), 134.30 (s), 139.91 (s), 158.80 (d), 158.92 (s), 160.24 (s). [d] MSCI (*i*-C_4H_{10}). [e] Hydrochloride.

of unreacted **5a**.[13] Discussion only in terms of thermodynamic preference for **5b**, however, would be incomplete, since the presence of a secondary amine (diisopropylamine on lithiation with LDA or piperidine on quenching with *N*-formylpiperidine) is necessary for the equilibration to occur.

Our attempts to prepare benzoyl derivatives of type **g** directly by trapping organometallics **b** with electrophiles were unsuccessful. Alternatively, **2–5g** were prepared in 94–98% yield by oxidation of alcohols **2–5c**. Heterocyclic derivatives of type **g** are useful in synthesis of heteropolycyclic compounds. Their synthetic utility as 1,3-dielectrophilic building blocks is illustrated by structures **10–12**, derived from **2g** by cyclocondensation with $RNHNH_2$ (R = H, Me), $PhNH_2$, and 1,2-phenylenediamine, respectively.



10a: R=H; **b**: R=Me



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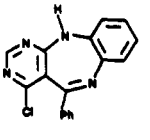

12

Experimental Section

Commercial solutions of *n*-BuLi (1.6 M) and *s*-BuLi (1.4 M) in hexanes were used. All air-sensitive reactions were conducted under an argon atmosphere. Organic extracts were dried with anhydrous Na_2SO_4, and solvents were removed under reduced pressure. Products were separated and purified by column chromatography on Merck Kieselgel 60 or Aluminum oxide (neutral, III) using CH_2Cl_2 or CH_2Cl_2/hexane as the eluent. For

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TLC, Merck aluminum sheets precoated with Kieselgel 60 F_{254} or Aluminum oxide F_{254} were used. For other general experimental information see ref 7. Physical and spectroscopic data of products are given in Table III.

General Procedure for the Lithiation of 1a-5a and Reaction with Electrophiles. Preparation of 1-6c-f and 7-9. A solution of the lithiating agent (5 mmol) in THF (5 mL) at -80 °C was treated dropwise with a solution of **1a-5a** (5 mmol) in THF (5 mL). The reaction mixture was stirred at -80 °C for 30 min, and then the electrophile (5 mmol) was added neat. The mixture was stirred for an additional 30 min then hydrolyzed by the addition of saturated aqueous NH_4Cl solution at -80 °C and extracted in ether.

General Procedure for the Oxidation of Alcohols 2c-5c. Preparation of 2g-5g. A solution of the alcohol **2c-5c** (2 mmol) in anhydrous acetone (6 mL) was treated portionwise with powdered CrO_3 (600 mg, 6 mmol) at 0 °C with vigorous stirring. The mixture was stirred for 10 min at rt, and then the excess oxidizing agent was destroyed by the addition of 2-propanol (1 mL), and stirring was continued for 10 min. The mixture was poured into saturated aqueous $NaHCO_3$ solution (30 mL). The solids were filtered off and washed with acetone (2 mL) and ether (50 mL). The product was extracted from the filtrates in ether.

4-Hydrazino-3-phenyl-1*H*-pyrazolo[3,4-*d*]pyrimidine (10a). A suspension of **1g** (253 mg, 1 mmol) in EtOH (3 mL) was treated with anhydrous hydrazine (0.08 mL, 2.5 mmol) with stirring. The solution was heated to reflux, filtered while hot, and concentrated. The product, which crystallized out, was filtered and washed with EtOH and ether; yield 84%.

1-Methyl-4-(1-methylhydrazino)-3-phenyl-1*H*-pyrazolo-[3,4-*d*]pyrimidine (10b). A suspension of **1g** (253 mg, 1 mmol) in MeOH (2 mL) was treated with methylhydrazine (0.26 mL, 5 mmol) with stirring. The mixture was stirred for 2 h at rt, the solvents were removed under reduced pressure, and the product was taken in ether; yield 80%.

5-Benzoyl-6-chloro-4-(phenylamino)pyrimidine. A solution of **1g** (506 mg, 2 mmol), aniline (0.22 mL, 2.4 mmol), and Et_3N (1 mL) in benzene (10 mL) was heated under reflux for 12 h and then left 16 h at rt. The solvents were removed under reduced pressure, and the product was taken in CH_2Cl_2. The solution was washed with water and dried (Na_2SO_4). The product was further purified by chromatography; yield 92%, mp 125-126 °C (CH_2Cl_2/hexane): ^1H NMR ($CDCl_3$) δ 7.14 (t, 1 H, J = 2.0 Hz), 7.33 (t, 2 H, J = 2.0 Hz), 7.44-7.56 (m, 4 H), 7.62 (t, 1 H, J = 2.0 Hz), 7.82 (d, 2 H, J = 2.0 Hz), 8.39 (s, 1 H), 8.52 (s, 1 H); ^{13}C NMR ($CDCl_3$) δ 112.88 (s), 122.08 (d), 124.96 (d), 128.81 (d), 129.20 (d), 134.14 (d), 137.17 (s), 157.96 (s), 158.37 (d), 159.19 (s), 194.63 (s). Anal. Calcd for $C_{17}H_{12}ClN_3O$: C, 65.92; H, 3.91; N, 13.57. Found: C, 66.28; H, 4.15; N, 13.66.

5-Phenylpyrimido[4,5-*b*]quinolin-4(3*H*)-one (11). A homogenized mixture of the previous product (310 mg, 1 mmol) and PPA (3.0 g) was heated at 100 °C bath temperature for 10 min. On cooling the mixture was hydrolyzed with water and neutralized with saturated aqueous K_2CO_3 solution. The product, which crystallized out, was filtered and washed with water and MeOH; yield 97%.

4-Chloro-5-phenyl-11*H*-pyrimido[4,5-*b*][1,5]benzodiazepine (12). A suspension of 1,2-phenylenediamine (130 mg, 1.2 mmol) in anhyd benzene (4 mL) was treated with Et_3N (0.14 mL, 1 mmol), and the mixture was stirred at 45 °C until a clear solution was formed. Then, a solution of **1g** (253 mg, 1 mmol) in benzene (3 mL) was added dropwise with stirring and the reaction mixture was refluxed for 1 h. Solvents were removed under reduced pressure and the product was purified by chromatography on silica gel using benzene/ether as the eluent; yield 87%.

Registry No. **1a**, 3934-20-1; **1c**, 130825-16-0; **1d**, 62803-30-9; **2a**, 1193-21-1; **2c**, 109574-98-3; **2d**, 134031-19-9; **2g**, 109575-04-4; **3a**, 3764-01-0; **3c**, 134031-16-6; **3d**, 134031-20-2; **3g**, 91546-44-0; **4a**, 26452-80-2; **4c**, 134031-17-7; **4d**, 134031-21-3; **4f**, 134031-24-6; **4g**, 134031-25-7; **5a**, 2402-78-0; **5c**, 58584-77-3; **5d**, 134031-22-4; **5e**, 58584-94-4; **5f**, 55304-73-9; **5g**, 118067-08-6; **6c**, 134031-18-8; **6d**, 134031-23-5; **6e**, 39621-00-6; **6f**, 113293-70-2; **7**, 54503-93-4; **8**, 134031-26-8; **9**, 134031-27-9; **10a**, 134031-28-0; **10b**, 134031-29-1; **11**, 31407-32-6; **12**, 134031-30-4; PhCHO, 100-52-7; Me_3SiC, 75-77-4; MeI, 74-88-4; *N*-formylpiperidine, 2591-86-8; hydrazine, 302-01-2; methylhydrazine, 60-34-4; aniline, 62-53-3; 1,2-phenylenediamine, 95-54-5; 5-benzoyl-6-chloro-4-(phenylamino)pyrimidine, 134031-31-5.

Supplementary Material Available: Regioselectivity of lithiation of **5a** as determined by reference addition to PhCHO and characterization data for previously reported compounds (2 pages). Ordering information is given on any current masthead page.

Silica Gel Supported Zinc Borohydride. 2.[1] Regioselective 1,2-Reduction of Conjugated Ketones and Aldehydes to the Corresponding Allylic Alcohols

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Received September 24, 1990

The supported-reagent technique has attracted considerable interest among synthetic chemists in recent years.[2] Advantages frequently claimed in favor of supported reagents compared with their homogeneous counterparts are increased yields, mild conditions, and clean and rapid reactions, but examples of regio-, stereo-, and chemoselective control using supported reagents are rather few.[3] We have recently introduced silica gel supported zinc borohydride for the regio- and stereoselective reductive cleavage of unsymmetrical epoxides[1] and herein wish to disclose another application of this reagent for regioselective 1,2-reduction of conjugated ketones and aldehydes.

Selective reduction of conjugated ketones and aldehydes to the corresponding allylic alcohols is a challenging problem, since it is usually associated with varying amounts of concomitant reduction of the double bonds. This leads to saturated alcohols and/or ketones, due to competing 1,2- vs 1,4-attack by hydride.[4] Considerable progress has been made in the development of various reducing agents for this purpose,[5] but few have proven very

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