Table III. Dehydrohalogenation of *vic*-Dihaloalkanes over Silica Gel

substrate	products	t (min)	yield by ^{1}H NMR Z	E
1o	(*Z*)-**2o** and (*E*)-**2o**	5	40	30
1o	(*Z*)-**2o** and (*E*)-**2o**	60	57	33
1o	(*Z*)-**2o** and (*E*)-**2o**	90	76	23
1p	(*Z*)-**2p** and (*E*)-**2p**	10	57	17
1p	(*Z*)-**2p** and (*E*)-**2p**	20	82	18
1p	(*Z*)-**2p** and (*E*)-**2p**	60	90	10
1q	(*Z*)-**2q** and (*E*)-**2q**	10	~50	~50
1r	(*Z*)-**2r** and (*E*)-**2r**	5	~50	~50

(M^+), 129 (100). Anal. Calcd: C, 79.52; H, 6.67; Cl, 13.81. Found: C, 79.38; H, 6.60; Cl, 13.92.

2-Bromo-1,1-bis(*p*-methylphenyl)propene (2j). The crude product was recrystallized from methanol, giving a white solid: mp 67–68 °C; ^{1}H NMR δ 2.27 (3 H, s), 2.34 (3 H, s), 2.37 (3 H, s), 6.88–7.35 (8 H, m); MS (70 eV) (*m/e*, relative intensity) 302 (4.2) (M^+), 300 (4.3) (M^+), 129 (100). Anal. Calcd: C, 67.78; H, 5.69; Br, 26.53. Found: C, 67.60; H, 5.48; Br, 26.90.

Reactions of 1,1-Asymmetrically Substituted Compounds 1o–r. Only the *Z* isomers of **2o,p** and the *E* isomers of **2q,r** could be isolated. After purification by column chromatography and recrystallization they were identified as described.[17-19] Elemental analyses, ^{1}H NMR, and mass spectra of the reaction mixtures were performed and compared with those of the pure isolated products. The results obtained show the presence of *E–Z* mixtures (Table III).

(*E*)-2-Bromo-1-(4-methylphenyl)-1-phenylethene (2r). This compound is described as a liquid in the literature;[18] we have obtained it as a solid: mp 56–57 °C (ethanol); ^{1}H NMR (Cl_4C) δ 2.35 (3 H, s), 6.62 (1 H, s), 6.92–7.40 (9 H, m); MS (70 eV) (*m/e*, relative intensity) 274 (100) (M^+), 272 (97) (M^+), 193 (60), 178 (65), 115 (75). Anal. Calcd: C, 65.85; H, 4.80; Br, 29.35. Found: C, 65.79; H, 4.92; Br, 29.95.

(*Z*)-3-Bromo-1,2-diphenylpropene (3). *erythro*-1,2-Dibromo-1,2-diphenylpropane (**1l**) was synthesized, isolated, and identified as described.[21] At the end of the reaction with silica gel the solution was filtered and the solvent removed. The mixture of allylic halides **3** and **3′** was analyzed by ^{1}H NMR spectroscopy and then vacuum distilled at 130–135 °C, 0.01 torr. Boiling point and analytical data agree with those in literature:[22] ^{1}H NMR δ 4.28 (2 H, s), 4.35 (2 H, br s), 6.61 (1 H, s), 6.77 (1 H, br s), 6.90–7.50 (10 H, m). The ^{1}H NMR spectra indicated that the isomers were formed in a 3/1 ratio. The distilled mixture was chromatographed through a column consisting of 15 g of silica gel placed over 105 g of alumina with *n*-hexane as eluent. As the halides decomposed only a minor amount of pure **3** was obtained as an oil. The *Z* geometry was assigned to the main product by comparing the ^{1}H NMR spectra of **3** and **3′** with the signals of vinylic and aromatic protons in *cis*- and *trans*-stilbenes and (*E*)-1,2-diphenylpropene.

^{1}H NMR of **3**: δ 4.35 (2 H, br s, CH_2Br), 6.77 (1 H, br s, C=CH), 6.90–7.50 (10 H, m, ArH); MS (25 eV) (*m/e*, relative intensity) 274 (3.5) (M^+), 272 (3.7) (M^+), 193 (45) (M^+ – Br), 192 (12) (M^+ – HBr) 115 (100) (M^+ – HBr – C_6H_5). Anal. Calcd: C, 65.95; H, 4.80. Found: C, 65.79; H, 4.70. Bromine was not titrated.

Registry No. **1a**, 40957-21-9; **1b**, 94611-18-4; **1c**, 59856-01-8; **1d**, 94611-16-2; **1e**, 94611-17-3; **1f**, 106403-85-4; **1g**, 106403-86-5; **1h**, 106403-87-6; **1i**, 106403-88-7; **1j**, 106403-89-8; **1k**, 106403-90-1; **1l**, 63904-71-2; **1m**, 13027-48-0; **1n**, 13440-24-9; **1o**, 106403-91-2; **1p**, 106403-92-3; **1q**, 106403-93-4; **1r**, 106403-94-5; **2a**, 13249-58-6; **2b**, 2592-73-6; **2c**, 781-34-0; **2d**, 781-32-8; **2e**, 22133-88-6; **2f**, 101414-10-2; **2g**, 97193-00-5; **2h**, 106403-95-6; **2i**, 81360-98-7; **2j**, 82357-51-5; **2k**, 39179-87-8; (*Z*)-**2o**, 15725-99-2; (*E*)-**2o**, 15726-00-8; (*Z*)-**2p**, 99632-23-2; (*E*)-**2p**, 99632-31-2; (*Z*)-**2q**, 15726-03-1; (*E*)-**2q**, 15726-04-2; (*Z*)-**2r**, 106403-96-7; (*E*)-**2r**, 106403-97-8; **3**, 106403-98-9; **3′**, 106403-99-0.

(21) Ruasse, M. F.; Argile, A. *J. Org. Chem.* **1983**, *48*, 202.
(22) Lüttringhaus, R.; Köning, H. B.; Böttcher, B. *Liebigs Ann. Chem.* **1948**, *560*, 213.

A Convenient Synthesis of C-Unsubstituted and C-Monoalkylated Ketene Imines by Dehydrocyanation of Imidoyl Cyanides Using Vacuum Gas-Solid Reactions

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Substituted ketene imines with at least one aromatic substituent on nitrogen or carbon are well-known and have been described extensively in the literature, especially in view of their potential to be used in cycloaddition reactions.[1] Specific synthetic approaches exist for the preparation of the parent compound,[2] the trisilylated analogue,[3] and the *N*-methyl[4] and *N*-*tert*-butyl[5] derivatives. Recently, a synthesis of trialkyl ketene imines using α-halo imino chemistry via base-induced elimination of hydrogen cyanide from α-cyano enamines was reported.[6] However, this method is not suitable for the preparation of less substituted ketene imines because of the difficulties in synthesizing the corresponding α-cyano enamine precursors.

We report now that aliphatic α-imidoyl cyanides are useful precursors for the general synthesis of the volatile C-unsubstituted and C-monosubstituted *N*-alkyl ketene imines by an appropriate dehydrocyanation using a vacuum gas–solid reaction (VGSR).[7]

Results and Discussion

Stable aliphatic α-imidoyl cyanides are accessible from N-chlorination/dehydrochlorination of α-amino nitriles, but the reported reaction conditions (*t*-BuOCl/Et_3N or DABCO)[8] are not compatible with the less substituted alkyl species (R^1 = H, Me; R = H, Me) due to extensive decomposition of the reaction products. However, by altering the reaction conditions, it was possible to synthesize these latter species in good yields (73–88%). The α-(*N*-alkylamino) nitrile precursors **1** were prepared by a classical Strecker synthesis (87–98%) involving condensation of an aldehyde (R^1 = H, Me) with a primary amine (R = H, Me) (under hydrochloride form) in the presence of sodium cyanide in aqueous methanol at −30 °C (Scheme I).[9] The conversion of α-amino nitriles **1** into α-imino nitriles **2** was accomplished in 73% overall yield by N-chlorination with *N*-chlorosuccinimide (NCS) followed by dehydrochlorination with solid potassium hydroxide. Both reactions were performed at −30 °C in tetraglyme because the intermediate α-(*N*-chloroamino) nitriles decompose violently (and often explosively!), even at 0 °C in solution. Hence, these labile *N*-chloroamino compounds were not isolated but immediately treated with a suspension of pulverized potassium hydroxide. The α-imino nitriles **2** thus formed were separated from tetraglyme by distillation at reduced pressure (10^{-2} torr). The water formed during the dehydrochlorination step is codistilled and finally separated by drying over molecular sieves. Imidoyl cyanides exist as the *Z* isomer exclusively (as evidenced by ^{1}H NMR analysis) except for the less substituted 2-(*N*-methylimino)propanenitrile **2a**, which showed also the

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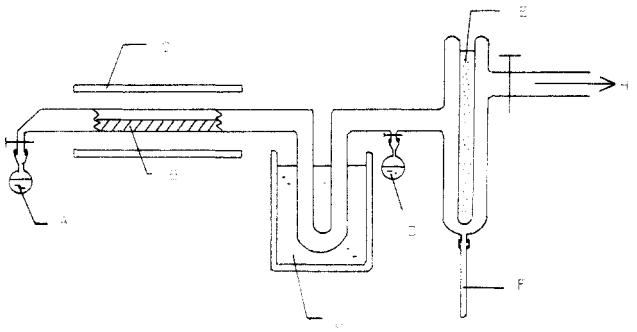
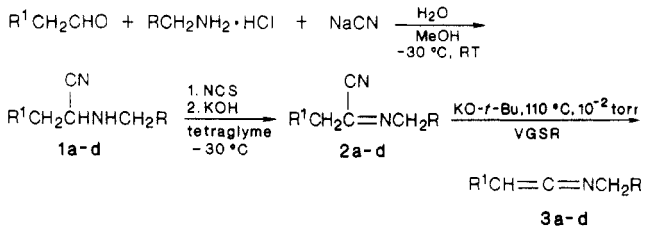


Figure 1. Apparatus used for vacuum gas–solid reactions (VGSR): A, introduction of the precursor; B, solid base (KO-*t*-Bu); C, oven (110 °C); D, introduction of the solvent; E, cold finger (liquid nitrogen); F, NMR tube; G, cold trap (−85 °C); H, vacuum line.

Scheme I[a]



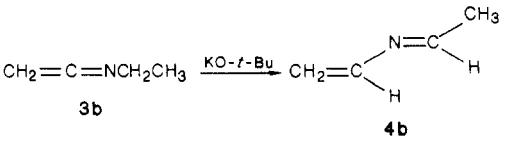
[a] Key: (**a**) R = H, R^1 = H; (**b**) R = Me, R^1 = H; (**c**) R = H, R^1 = Me; (**d**) R = Me, R^1 = Me.

presence of 5% of the *E* isomer.

The dehydrocyanation of α-imino nitriles was worked out by the VGSR technique. The apparatus is described in Figure 1. The imidoyl cyanides **2** were passed in the gaseous phase (by evaporating in vacuo) over solid potassium *tert*-butoxide (*t*-BuOK) at 110 °C. The *tert*-butyl alcohol formed was first eliminated by a cold trap at −85 °C, and the products were condensed on a cold finger at liquid-nitrogen temperature. In a pilot reaction, 2.61 g of the crude ketene imine **3a** (purity higher than 80%) was obtained in 61% yield.

Compounds **3** were stable for several days in solution at room temperature, but they decomposed slowly in the absence of solvent (half-life for **3a** 12 h at 20 °C). They were fully characterized by IR, NMR, and mass spectroscopy. The most remarkable features of the NMR data were the high-field position of the sp^2 carbon and the low-field position of the sp carbon (e.g., 33.6 and 188.9 ppm, respectively, for **3a**[10]). These values indicate that the structure $H_2\ddot{C}^-—C\equiv N^+—$, like the corresponding mesomeric structure $H_2\ddot{C}^-—C\equiv O^+$ of the ketene function[11]

Scheme II



contributes significantly to the ground state.

Small amounts (≃5%) of unstable ketene imine isomers were observed when the NMR spectra were run at low temperature (<−60 °C); the only well-characterized minor product was the 2-aza-1,3-butadiene **4b**, as evidenced by comparison of the ^1H and ^{13}C NMR data with those of an authentic sample.[12] Although potassium *tert*-butoxide has been widely used in isomerization of unsaturated compounds,[13] base-promoted isomerization of ketene imines has not been observed before (Scheme II). However, this reaction cannot be considered as a potential route to 2-azabutadienes since further isomerizations occur in the case of 3-substituted ketene imines **3c** and **3d**, leading to a complex mixture.

In conclusion, it was demonstrated that the VGSR technique applied to the dehydrocyanation of α-imino nitriles constituted a suitable preparative method for the gram-scale synthesis of C-unsubstituted and C-monosubstituted ketene imines. Owing to their unexpected stability, these compounds can be easily used for further reactions.

Experimental Section

IR spectra were obtained with a Perkin-Elmer Model 157 G spectrophotometer. ^1H and ^{13}C NMR spectra were recorded on a Bruker WP 80 DS or Bruker WP 80 spectrometer.

The preparation of compound **1a** is representative of all syntheses of α-(*N*-alkylamino) nitriles **1**.

2-(*N*-Methylamino)propanenitrile (1a). To a solution of 0.2 mol (13.5 g) of methylamine hydrochloride and 0.2 mol (9.8 g) of sodium cyanide in a mixture of 40 mL of water and 40 mL of MeOH was added dropwise 0.18 mol (7.9 g) of freshly distilled acetaldehyde at −30 °C. After stirring for 10 min at −30 °C, the reaction mixture was allowed to warm to room temperature. After 10 min at room temperature, 2-(*N*-methylamino)propanenitrile (**1a**) was extracted with ether and dried ($MgSO_4$). Evaporation of the solvent in vacuo afforded **1a**. As almost no impurities (<2%) were present, this compound was used as such in the next step; yield 26.3 g (87%). Distillation was possible but strongly reduced the yield; bp 60–68 °C (22–24 mmHg).

The preparation of compound **2a** is representative of all other preparations of imidoyl cyanides **2**.

2-(*N*-Methylimino)propanenitrile (2a). To a solution of 0.06 mol (5.04 g) of 2-(*N*-methylamino)propanenitrile (**1a**) in 30 mL of tetraglyme at −30 °C under a nitrogen atmosphere was added 0.06 mol (8.01 g) of *N*-chlorosuccinimide. During 30 min, the temperature raised to −15 °C and the succinimide was subsequently filtered off under a nitrogen pressure at −15 °C. The precipitate was washed at −15 °C with 15 mL of cold tetraglyme. The filtrate was cooled to −30 °C, and 0.072 mol (4.03 g) of pulverized KOH was added. After the reaction mixture warmed to room temperature over a period of 1 h, the precipitate was filtered off under nitrogen pressure, and the α-imino nitrile **2a** was distilled from the tetraglyme under vacuum (10^{-2} torr; bath temperature 60 °C). The water formed in the last reaction step was separated with a pipet and the 2-(*N*-methylimino)propanenitrile (**2a**) dried over molecular sieves (3 Å): yield 3.58 g (73%); IR (NaCl) 2210 (C≡N), 1642 cm^{-1} (C=N); ^1H NMR ($CDCl_3$) (*Z* isomer; 95%) δ 2.25 (q, 3 H, CH_3C=N, ^5J = 1.7 Hz), 3.51 (q, 3 H, ^5J = 1.7 Hz, CH_3N), (*E* isomer; 5%) 2.09 (q, 3 H, CH_3C=N, ^5J = 1.2 Hz), 3.31 (q, 3 H, ^5J = 1.2 Hz, CH_3N); ^{13}C NMR ($CDCl_3$)

(1) Krow, G. R. *Angew. Chem., Int. Ed. Engl.* **1971**, *10*, 435.
(2) Guillemin, J. C.; Denis, J. M.; Lasne, M. C.; Ripoll, J. L. *J. Chem. Soc., Chem. Commun.* **1983**, 238.
(3) Gornowicz, G. A.; West, R. *J. Am. Chem. Soc.* **1971**, *93*, 1714.
(4) Ripoll, J. L.; Thuillier, A. *Tetrahedron Lett.* **1978**, 463.
(5) Fuks, R.; Baudoux, D. 4th International Conference on Organic Synthesis, Tokyo, Japan, 1982; Abstract A-II-2101.
(6) De Kimpe, N.; Verhé, R.; De Buyck, L.; Chys, J.; Schamp, N. *J. Org. Chem.* **1978**, *43*, 2670.
(7) For a description of this technique, see: Guillemin, J. C.; Denis, J. M. *Angew. Chem., Int. Ed. Engl.* **1982**, *21*, 690; *Angew. Chem. Suppl.* **1982**, 1515.
(8) De Kimpe, N.; Verhé, R.; De Buyck, L.; Chys, J.; Schamp, N. *Synthesis* **1978**, 895.
(9) Béjaud, M.; Mion, L.; Taillades, J.; Commeyras, A. *Tetrahedron* **1975**, *31*, 403.
(10) NMR coupling constants allow us to attribute for the sp^2 and sp^3 carbons of **3a** an opposite assignment than previously reported.[4]
(11) Firl, J.; Runge, W. *Angew. Chem., Int. Ed. Engl.* **1973**, *12*, 668. See also: Olah, G. A.; Denis, J. M.; Westerman, P. W. *J. Org. Chem.* **1974**, *39*, 1206.
(12) For the synthesis and thermal isomerization of 2-aza-1,3-butadienes, see: Malecot, Y. M.; Ripoll, J. L.; Thuillier, A. *J. Chem. Res. Synop.* **1983**, 86; *J. Chem. Res. Miniprint* **1983**, 959.
(13) Pearson, D. E.; Buehler, C. A. *Chem. Rev.* **1974**, *74*, 45.

δ 25.2 (q, CH_3C=N), 45.3 (q, CH_3N), 110.7 (s, C≡N), 141.5 (s, C=N); MS, *m/z* (relative intensity) 82, M^+ (28), 67 (100), 56 (23), 54 (11), 52 (11); high-resolution mass spectrum for $C_4H_6N_2$, calcd 82.0531, found 82.0531.

2-(*N*-Ethylimino)propanenitrile (2b): IR (NaCl) 2220 (C≡N), 1640 cm^{-1} (C=N); ^1H NMR ($CDCl_3$) δ 1.31 (q, 3 H, CH_3CN, ^3J = 7.2 Hz), 2.31 (t, 3 H, CH_3C=N, ^5J = 1.3 Hz), 3.78 (qq, 2 H, CH_2N, ^3J = 7.2 Hz, ^5J = 1.3 Hz); ^{13}C NMR ($CDCl_3$) δ 15.2 (q, CH_3CN), 25.3 (q, CH_3C=N), 53.2 (t, NCH_2), 110.8 (s, C≡N), 139.4 (s, C=N); yield 80%; MS, *m/z* (relative intensity) 96, M^+ (7), 85 (62), 83 (100), 81 (49), 59 (68), 58 (17), 47 (29); high-resolution mass spectrum for $C_5H_8N_2$, calcd 96.0687, found 96.0692.

2-(*N*-Methylimino)butanenitrile (2c): IR (NaCl) 2210 (C≡N), 1638 cm^{-1} (C=N); ^1H NMR ($CDCl_3$) δ 1.23 (q, 3 H, CH_3, ^3J = 7.2 Hz), 2.59 (qq, 2 H, CH_2, ^3J = 7.2 Hz, ^5J = 1.5 Hz), 3.58 (t, 3 H, CH_3N, ^5J = 1.5 Hz); ^{13}C NMR ($CDCl_3$) δ 9.9 (q, CH_3C), 32.1 (t, CH_2), 45.3 (q, NCH_3), 110.4 (s, C≡N), 146.8 (s, C=N); yield 88%; MS, *m/z* (relative intensity) 96, M^+ (20), 95 (15), 67 (100); high-resolution mass spectrum for $C_5H_8N_2$, calcd 96.0687, found 96.0692.

2-(*N*-Ethylimino)butanenitrile (2d): IR (NaCl) 2210 (C≡N), 1640 cm^{-1} (C=N); ^1H NMR δ 1.26 and 1.31 (2 t, 2 × 3 H, 2 CH_3, ^3J = 7.2 Hz), 2.57 (2 q, 2 × 2 H, 2 CH_2, ^3J = 7.2 Hz); ^{13}C NMR ($CDCl_3$) δ 10.0 (q, CH_3C=N), 15.3 (q, $NCCH_3$), 32.1 (t, CH_2C=N), 53.0 (t, NCH_2), 110.4 (s, C≡N), 144.8 (s, C=N); yield 86%; MS, *m/z* (relative intensity) 110, M^+ (8), 95 (100), 85 (12), 83 (17), 81 (34), 68 (21), 29 (72); high-resolution mass spectrum for $C_6H_{10}N_2$, calcd 110.0844, found 110.0840.

Synthesis of Ketene Imines 3a–d. Only analytical samples (0.5 g) of ketene imines **3b–d** were prepared. In a testing experiment, a gram-scale synthesis of ketene imine **3a** was performed. Purity of the crude products was higher than 80% (main impurities: *t*-BuOH and isobutene). The NMR spectra were recorded first at −50 °C and then at the probe temperature while IR spectra were measured at room temperature.

The preparation of compound **3a** is representative of all other preparations of ketene imines **3**.

With the apparatus previously described (Figure 1), the dehydrocyanation of **2a** into **3b** was performed by evaporating 0.063 mol (5.17 g) of imidoyl cyanide from flask A (10^{-3} mmHg, no heating) and passing it over potassium *tert*-butoxide (B) (40 g) in a tube heated at 110 °C. *tert*-Butyl alcohol was captured in the cold trap at −85 °C (G). Ketene imine **3a** was condensed onto a cold finger (liquid-N_2 temperature) (E) and collected in vessel F. The crude product (2.61 g) contains *t*-BuOH (<10%) and isobutene (≃5%). The yield of this reaction is about 61%.

***N*-Methyl ketene imine (ethenylidenemethylamine, 3a)**: yield 65% (NMR); IR (NaCl) 2035 cm^{-1} (C=C=N); ^1H NMR ($CDCl_3$) δ 3.04 (q, 2 H, CH2, ^5J = 2.4 Hz), 3.15 (t, 3 H, NCH_3, ^5J = 2.4 Hz); ^{13}C NMR ($CDCl_3$) δ 33.6 (t, CH_2, $J_{^{13}C-H}$ = 173.4), 39.5 (q, CH_3, $J_{^{13}C-H}$ = 140.3), 188.9 (s, =C=); high-resolution mass spectrum for C_3H_5N, calcd 55.0422, found 55.0427.

***N*-Ethyl ketene imine (ethenylideneethylamine, 3b)**: yield 61% (NMR); IR (NaCl) 2030 cm^{-1} (C=C=N); ^1H NMR ($CDCl_3$) δ 1.31 (q, 3 H, CH_3, ^3J = 7.0 Hz), 3.20 (t, 2 H, CH_2=, ^5J = 2.6 Hz), 3.47 (q, 2 H, CH_2N, ^3J = 7.0 Hz, ^5J = 2.6 Hz); ^{13}C NMR ($CDCl_3$) δ 14.9 (q, CH_3), 35.0 (t, CH_2=), 46.7 (t, NCH_2), 187.7 (s, =C=); high-resolution mass spectrum for C_4H_7N, calcd 69.0578, found 69.0573.

***N*-Methyl methylketene imine (1-propen-1-ylidenemethylamine, 3c)**: yield 60% (NMR); IR (NaCl) 2015 cm^{-1} (C=C=N); ^1H NMR ($CDCl_3$) δ 1.63 (d, 3 H, CH_3CH=, ^3J = 7.0 Hz), 3.16 (d, 3 H, NCH_3, ^5J = 2.2 Hz), 3.50 (m, 1 H, CH=); ^{13}C NMR ($CDCl_3$) δ 8.9 (q, CH_3CH=), 40.5 (q, CH_3N), 45.2 (d, CH=), 193.9 (s, =C=); MS, *m/z* (relative intensity) 69, M^+ (68), 68 (100), 58 (52), 42 (80), 41 (26), 39 (18), 29 (22), 28 (28), 27 (31); high-resolution mass spectrum for C_4H_7N, calcd 69.0578, found 69.0576.

***N*-Ethyl methylketene imine (1-propen-1-ylideneethylamine, 3d)**: yield 65% (NMR); IR (NaCl) 2020 cm^{-1} (C=C=N); ^1H NMR ($CDCl_3$) δ 1.28 (t, 3 H, $NCCH_3$, ^3J = 7.0 Hz), 1.63 (d, 3 H, CH_3CH=, ^3J = 6.0 Hz), 3.40 (qd, 2 H, NCH_2, ^3J = 7.0 Hz, ^5J = 2.4 Hz), 3.55 (qt, 1 H, CH_3CH, ^3J = 6.0 Hz, ^5J = 2.4 Hz); ^{13}C NMR ($CDCl_3$) δ 9.2 (q, CH_3CH=), 15.8 (q, $NCCH_3$), 47.0 (d, CH=), 47.7 (t, NCH_2), 192.1 (s, =C=); MS, *m/z* (relative intensity) 83, M^+ (47), 59 (51), 55 (70), 54 (100), 41 (3); high-resolution mass spectrum for C_5H_9N, calcd 83.0735, found 83.0736.

Registry No. **1a**, 16752-54-8; **1b**, 40651-88-5; **1c**, 106588-24-3; **1d**, 29151-31-3; (*Z*)-**2a**, 106588-25-4; (*E*)-**2a**, 106588-31-2; **2b**, 106588-26-5; **2c**, 106588-27-6; **2d**, 106588-28-7; **3a**, 67533-87-3; **3b**, 106588-29-8; **3c**, 63742-01-8; **3d**, 106588-30-1; MeCHO, 75-07-0; $MeNH_2$·HCl, 593-51-1.

Ruthenium Tetraoxide Phase-Transfer-Promoted Oxidation of Secondary Alcohols to Ketones[1]

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Oxidations of secondary alcohols to ketones constitute an important class of organic reactions, and there are a variety of reagents available for carrying out these conversions. Notable among these reagents are those employing chromium under acidic[2,3] or nonacidic conditions,[4-7] methyl sulfoxide based reagents,[8-11] and ruthenium tetraoxide.[12-16] However, problems are often associated with the use of each of these reagent types. Methyl sulfoxide reagents often give unwanted and difficult to remove side reaction products, particularly the methyl thiomethyl ether of the starting alcohol. The use of pyridinium dichromate and pyridinium chlorochromate on a large scale is made difficult because of the column chromatography required to separate reduced chromium products from the desired ketones. The well-known Jones reagent,[3] an acidic chromium reagent, is limited to those alcohols and/or product ketones not labile to the acidic conditions of the reaction.

Ruthenium tetraoxide, generated in situ from activated ruthenium dioxide[15] and periodate[14] or hypochlorite[15] in a water–chloroform system, has also been used for secondary alcohol to ketone conversions. Such ruthenium tetraoxide systems circumvent the problems associated with the previously mentioned oxidizing agents but poorly

(1) Presented at the 13th International Carbohydrate Symposium, Ithaca, NY, August 10–15, 1986.

(2) Wiberg, K. B. *Oxidation in Organic Chemistry*; Academic Press: New York, 1965.
(3) Bowden, K.; Heilbron, I. M.; Jones, E. R. H.; Weedon, B. C. L. *J. Chem. Soc.* **1946**, 39.
(4) Poos, G. I.; Arth, G. E.; Beyles, R. E.; Sarret, L. H. *J. Am. Chem. Soc.* **1953**, *75*, 422.
(5) Collins, J. C.; Hess, W. W.; Frank, F. J. *Tetrahedron Lett.* **1968**, 3363.
(6) Corey, E. J.; Suggs, W. *Tetrahedron Lett.* **1975**, 2647.
(7) Corey, E. J.; Schmidt, G. *Tetrahedron Lett.* **1979**, 399.
(8) Pfitzner, K. E.; Moffatt, J. G. *J. Am. Chem. Soc.* **1963**, *85*, 3027.
(9) Onodera, K.; Hirano, S.; Kashimura, N. *J. Am. Chem. Soc.* **1965**, *87*, 4651.
(10) Albright, J. D.; Goldman, L. *J. Am. Chem. Soc.* **1965**, *87*, 4214.
(11) Omura, K.; Swern, D. *Tetrahedron* **1978**, *34*, 1651.
(12) Courtney, J. L.; Swansborough, K. F. *Rev. Pure Appl. Chem.* **1972**, *22*, 47.
(13) Baker, D. C.; Horton, D.; Tindall, C. G., Jr. *Carbohydr. Res.* **1972**, *24*, 192.
(14) Baker, D. C.; Horton, D.; Tindall, C. G., Jr. *Methods Carbohydr. Chem.* **1976**, *7*, 3.
(15) Stevens, C. L.; Bryant, C. P. *Methods Carbohydr. Chem.* **1972**, *6*, 337.
(16) Kiersznicki, T.; Karuga, B.; Szeja, W. Pol. Pat. 121 419, 1982; *Chem. Abstr.* **1985**, *103*, 71612g.

0022-3263/87/1952-1149$01.50/0