Electrophilic Amination of Higher Order Cuprates with *N,O*-Bis(trimethylsilyl)hydroxylamine†

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Received April 26, 1993●

In the reaction of higher order cyanocuprates with *N,O*-bis(trimethylsilyl)hydroxylamine delivery of the $NHSiMe_3$ moiety to one of the anionic ligands in the cuprate takes place even in the absence of external bases according to an "electrophilic amination" protocol. Details of the methodology are given, and the reaction mechanism is analyzed in terms of interception by a mixed bis-metal cluster of a lithium *N*-silyl-*N*-siloxyamide, followed by intramolecular C–N coupling. This method is applicable to cyanocuprates bearing aromatic, heteroaromatic, and saturated aliphatic ligands. A number of 2-amino-substituted heterocycles, not easily accessible by normal routes, can be obtained with the aid of a stabilizing silylation at the nitrogen atom.

Introduction

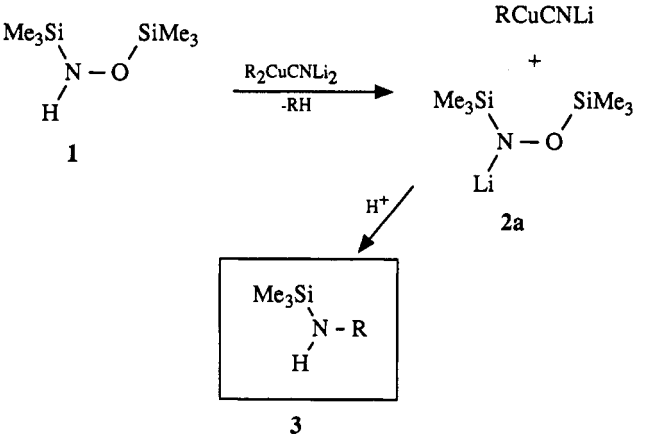
Since the discovery that organolithium compounds can be aminated with methyllithium–methoxamine, the original reaction by Sheverdina and Kocheshkov[1] has been used in a number of laboratories. The importance of primary amines as synthetic intermediates and as entries into biologically active natural compounds has created the need for new aminating reagents, capable of combination with a number of organometallics, and detailed reviews on this subject have appeared[2–7] which outline the variable efficiency of the *umpolung* introduction of an amino group into various organometallic compounds.

However, although great emphasis has been placed on organolithium[7,8a,b] and Grignards[1,7,9] as the organometallics to be aminated, with very few exceptions,[8a,10] the use of organocuprates has been neglected in spite of their importance[11] in synthesis.

Results and Discussion

As a part of our recent interest in organocopper chemistry,[12] a new organocuprate-aided amination protocol

Scheme I



has been developed, based on *N,O*-bis(trimethylsilyl)-hydroxylamine (1) as the source of the primary amino functionality.

The procedure, exemplified by the reaction outlined in Scheme I, affords amino derivatives **3** in good yields (Tables I and II). The overall process shows that 1 in the presence of higher order (HO) organocuprates[13] behaves as suitable synthetic equivalent of the "$Me_3Si–NH^+$" synthon, with a formal displacement of a Me_3SiO group from 1 under very mild conditions. It is worth noting that the results in Table I, which refer to aromatic and heteroaromatic systems, indicate the presence of the amino derivatives as the sole reaction products while, when the same procedure was applied to HO cuprates originating from aliphatic saturated organolithiums, compounds **3** were formed, together with varying amounts (5% to 18%) of the corresponding hydroxy derivatives (Table II).

The main synthetic interest of the results shown in Table I relates to the amination of heterocyclic ring systems. In particular, the synthesis of 2-aminobenzo[*b*]thiophene (**3d**) *via* electrophilic amination outlines a shorter route to this

† This work is dedicated to Professor Antonino Fava on the occasion of his 70th birthday.

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● Abstract published in *Advance ACS Abstracts*, September 1, 1993.

(1) Sheverdina, N. I.; Kocheshkov, Z. *J. Gen. Chem. USSR* **1938**, *8*, 1825.

(2) Kovacic, P.; Lowry, M. K.; Field, K. W. *Chem. Rev.* **1970**, *70*, 639.

(3) Wallace, R. G. *Aldrichim. Acta* **1980**, *13*, 3.

(4) Tamura, Y.; Minamikawa, J.; Ikeda, M. *Synthesis* **1977**, 1.

(5) Cenini, S.; La Monica, G. *Inorg. Chim. Acta* **1976**, *18*, 279.

(6) Scriven, E. F. V.; Turnbull, K. *Chem. Rev.* **1988**, *88*, 298.

(7) Erdik, E.; Ay, M. *Chem. Rev.* **1989**, *89*, 1947.

(8) (a) Beak, P.; Selling, G. W. *J. Org. Chem.* **1989**, *54*, 5574 and references cited therein. (b) Boche, G.; Mayer, N.; Bernheim, M.; Wagner, K. *Angew. Chem., Int. Ed. Engl.* **1978**, *17*, 7.

(9) Brown, R.; Jones, W. G. *J. Chem. Soc.* **1946**, 781. Gilman, H.; Avakian, S. *J. Am. Chem. Soc.* **1946**, *68*, 580.

(10) Yamamoto, H.; Maruoka, K. *J. Org. Chem.* **1980**, *45*, 2739.

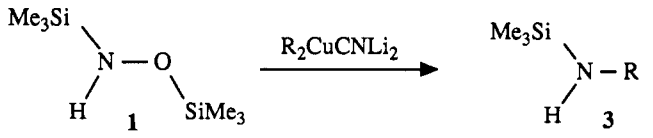
(11) Nakamura, E. *Synlett* **1991**, 539 and references cited therein.

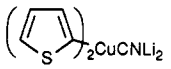
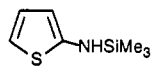
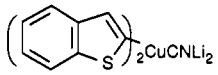
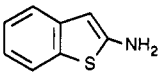
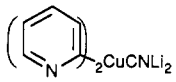
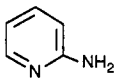
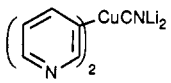
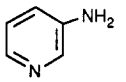
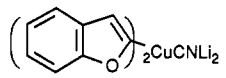
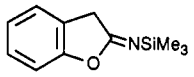
(12) Capella, L.; Degl'Innocenti, A.; Mordini, A.; Reginato, G.; Ricci, A.; Seconi, G. *Synthesis* **1991**, 1201. Degl'Innocenti, A.; Stucchi, E.; Capperucci, A.; Mordini, A.; Reginato, G.; Ricci, A. *Synlett* **1992**, *329*, 332. Casarini, A.; Joussaume, B.; Lazzari, D.; Porciatti, E.; Reginato, G.; Ricci, A.; Seconi, G. *Synlett* **1992**, 981.

(13) Throughout this paper these organocuprates are described as "higher order". This name simply refers to a well-established terminology and is in no way an attempt to impose any kind of arbitrary classification of the compounds. This matter is, in fact, still a question of debate in the scientific literature.

0022-3263/93/1958-5620$04.00/0

Table I. Electrophilic Amination of Cyanocuprates with 1



entry	cuprate	product (3)	yield[a] (%)
1	$Ph_2CuCNLi_2$	a $PhNH_2$	90[b]
2	$(p\text{-}OMeC_6H_4)_2CuCNLi_2$	b $p\text{-}OMeC_6H_4NH_2$	70[b]
3		c 	72[c]
4		d 	58[b]
5		e 	60[b]
6		f 	58[b]
7		g 	70[c]

[a] Isolated yield. [b] Hydrolytic workup. [c] Nonhydrolytic workup.

Table II. Amination–Hydroxylation of Cyanocuprates Bearing Aliphatic Saturated Ligands

$R_2CuCNLi_2$ R =	RNH_2 yield[a,b] (%)	ROH yield[c] (%)
n-Bu	48	18
s-Bu	60	5
t-Bu	80	10

[a] Isolated yield; average of three or more runs. [b] Isolated as benzamide (see Experimental Section). [c] Gas chromatographic yields after conversion to benzoic esters (see Experimental Section).

compound with respect to the five-step sequence previously reported[14] with increased yields. Furthermore, the formation of *N*-(trimethylsilyl)-2-aminothiophene (**3c**) affords a straightforward and easy entry to a new protected form of the otherwise unstable free base.[15] With benzofuran the aminated derivative 2-[(trimethylsilyl)imino]-2(3*H*)-benzofuranone (**3g**) is formed, due to a chain tautomerism. The isolation of these last two elusive compounds takes advantage of the stabilizing effect of the NH–$SiMe_3$ framework in the title reaction.

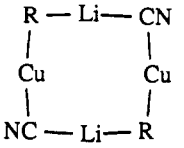
The amination experiments were carried out by adding the organolithium derivative to a suspension of CuCN in THF or ether cooled at −50 °C followed by addition of 1, and the best yields were obtained with RLi–CuCN–1 ratios of 2:1:1, which correspond[16] to the generation of a HO dianionic cuprate, $R_2CuCNLi_2$. It is worth noting that, in the absence of any added metal salt, the reaction of 1 with RLi leads to the silylated derivatives $RSiMe_3$ as the sole detectable reaction products, whereas with Grignard reagents, an oxysilylation process predominates.[17]

When a Gilman-type cuprate Ph_2CuLi is used, the yield of aniline is only slightly lower (80%) with respect to that (90%) obtained (Table I) with a HO cyanocuprate.

Mechanistic consideration of the Sheverdina–Kocheshkov reaction, as well as extensive studies by Beak and co-workers,[8,18a,b] have suggested that 1 equiv of the organometallic may act as a base to generate an alkoxyamide from *N*-alkoxyamines and *N*-alkyl-*N*-alkoxyamines, which can then aminate organolithium reagents through a SN_2 reaction pathway within a lithium complex.

The use of HO homocuprates which rely upon organometallic species bearing the base as well as the group to be delivered to the nitrogen moiety, and with two metals having some affinity for nitrogen, meets all the previously outlined requirements for the introduction of nitrogen to donor sites.

Accordingly, the formation of a lithium *N*-silyl-*N*-siloxyamide **2a** from 1 can be easily envisioned with consumption of one of the anionic ligands in the HO cuprate in the first step of the reaction. This path being common to all the cuprates so far investigated, the newly formed mono anionic lower-order (LO) cuprate would give rise to a *highly organized mixed metal cluster*[19] **4**



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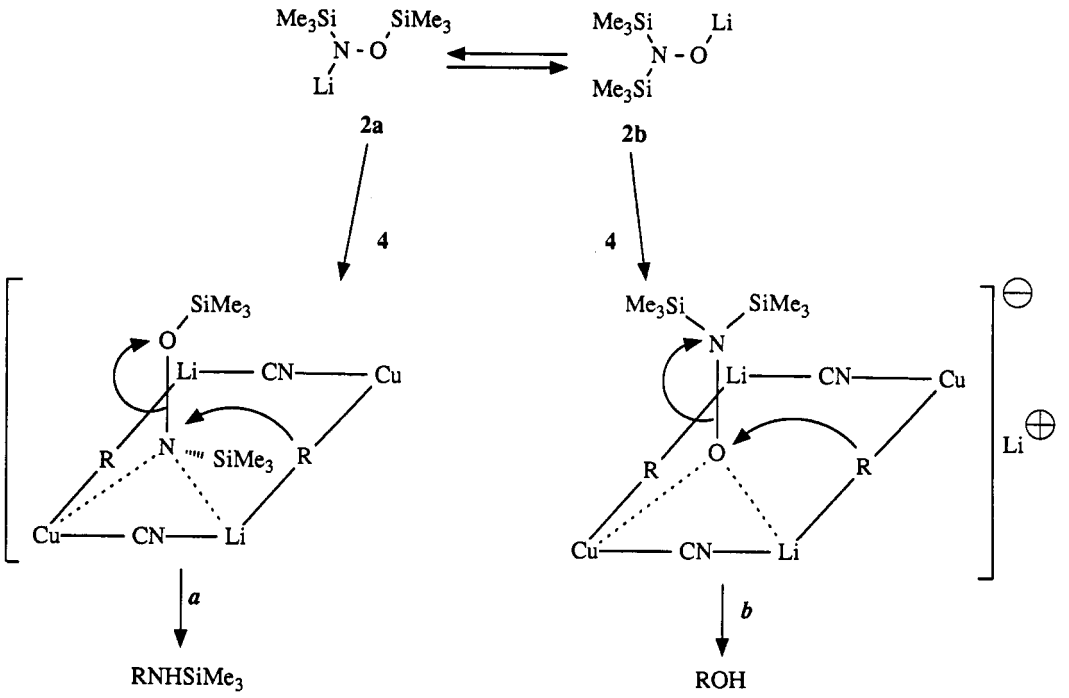
consisting of a metal core to which each of the ligands is bound *via* C(1) to two metals by a three-center two-electron bond,[20] analogous to the "ate" complexes previously reported[21] by Van Koten and co-workers. The architecture of this complex, after interaction with the amide **2a**, might account for the formation of the asymmetric coupling products, a pathway which is not unprecedented[10,22] in the organocopper series. The generation of new C–N or C–O bonds can be tentatively rationalized according to Scheme II by also taking into consideration the equilibrium **2a** ⇄ **2b** between the rearranged and unrearranged anions of 1, previously described by West.[23] It is therefore reasonable to assume that the amide **2a** once formed would be immediately intercepted by *cluster* **4** *via* Cu–N coordination: the collapse of this newly formed aggregate might lead to the formation of the C–N bond as in **3**, through path a, this path being particularly favored when R are aromatic or heteroaromatic groups.[24] The formation of the hydroxy derivatives, although in small amounts, encountered when R in the HO cuprates are aliphatic

(14) Stacy, G. V.; Villaescusa, F. W.; Wollner, T. E. *J. Org. Chem.* **1965**, *30*, 4074.
(15) Binder, D.; Habison, G.; Noe, C. R. *Synthesis* **1977**, 255.
(16) Lipshutz, B. H. *Synlett* **1990**, 119 and references cited therein.
(17) The synthetic potential and the mechanism of this reaction are now being actively investigated in our laboratory.
(18) (a) Beak, P.; Kokko, B. *J. Org. Chem.* **1982**, *47*, 2822. Beak, P.; Basha, A.; Kokko, B.; Loo, D. K. *J. Am. Chem. Soc.* **1986**, *108*, 6016.
(19) The proposal for dimeric structures in LO cuprates has been confirmed by molecular weight determinations and NMR spectroscopy and amply demonstrated by X-ray crystallography: Snyder, J. P.; Tipsword, G. E.; Spangler, D. P. *J. Am. Chem. Soc.* **1992**, *114*, 1507 and references cited therein.
(20) Although literature data suggest a higher stability with aromatic groups, a structure in LO cuprates in which the alkyl bridge again involves a three-center two-electron bond, with linear coordination at copper, has also been demonstrated: Jarvis, J. A. J.; Kilbourn, B. T.; Pearce, R.; Lappert, M. F. *J. Chem. Soc., Chem. Commun.* **1973**, 475.
(21) Van Koten, G.; Jastrzebski, J. T. B. H.; Noltes, J. G. *J. Organomet. Chem.* **1977**, *140*, C23. Van Koten, G.; Noltes, J. G. *J. Am. Chem. Soc.* **1979**, 101, 6593.
(22) Ten Hoedt, R. W. M.; Noltes, J. G.; Van Koten, G.; Spek, A. L. *J. Chem. Soc., Dalton Trans.* **1978**, 1800.
(23) West, R.; Boudjouk, P. *J. Am. Chem. Soc.* **1973**, *95*, 3987.
(24) The oxidation potential data for Ph (<−0.1 V) and Me (−0.5 V) (Eberson, L. In *Electron transfer reactions in Organic Chemistry*; Springer: Berlin, 1987) suggest a decrease in *hardness* in moving from the aromatic to the aliphatic series and therefore support a more favorable interaction of aromatic and heteroaromatic ligands as compared with that of the alkyl groups with the *harder* N heteroatom.

Scheme II



saturated frameworks, can be accounted for by the occurrence of a competitive reaction starting with coordination between **4** and **2b** *via* Cu–O interaction and the subsequent collapse of the aggregate *via* path b, which could explain the formation of the siloxy derivatives. In both cases, paths a and b would take advantage, respectively, in the title reaction, of the presence of $OSiMe_3$ and $N(SiMe_3)_2$ as the leaving groups and of the possibility of metal bridging which would place the nucleophilic ligand in the appropriate position in the metal–substrate complex. Further support for path b comes from the recovery, besides the siloxy derivatives, of sizeable amounts of hexamethyldisilazane.

The above mechanistic hypotheses, which closely follow the approach clearly delineated by Beak et al., although at the moment rather speculative, are to some extent substantiated by the observation of the lowering of yields when *N,N,O*-tris(trimethylsilyl)hydroxylamine or LO monoanionic cuprates, corresponding to a 1:1 ratio between PhLi and CuCN, are used. In the first case removal of the Me_3Si group by one of the ligands at Cu is more difficult than for a proton, and when 1 equiv of LO cuprate is used at least half of it is consumed in the preliminary deprotonation step leading to conversion yields not exceeding 35%.

When a Gilman cuprate is used, a plausible hypothesis is that **1** might again interact with the dimeric cuprate, probably replacing a solvent molecule at one of the metal centers: deprotonation of **1** could follow, *via* a mechanism in which extraction of the proton by one of the Ph ligands is concerted with an intramolecular substitution path, very similar to that depicted in Scheme II. Alternatively, a formal generation of a hydroxy amidocuprate, due to the displacement of a Ph ligand by the hydroxylamine, could be taken into consideration.

Finally, the use of a mixed HO cuprate with the stoichiometric composition *n*-$BuPhCuCNLi_2$, bearing two different transferable ligands, when reacted with **1** under the usual conditions, led to a mixture of $PhNHSiMe_3$ (50%), *n*-$BuNHSiMe_3$ (35%), and *n*-BuOH (5%) which relies on the mutual role played respectively by the *n*-Bu– or by the Ph– as a base in the first step of the reaction and to the complementary delivery of the remaining ligand.

Conclusion

The present work provides an efficient method for the amination of a wide range of organocuprates. The mildness and simplicity and the fact that, unlike other methods for electrophilic amination, no large excess of base is needed allow a high degree of variability of the ligands to be transferred and are the most valuable assets of this reaction.

Furthermore, the evidence that this formal displacement may proceed within an aggregate between a lithium amide and a bis-metallic cluster discloses interesting perspectives for the extension of an approach which should be widely applicable to the combinations of other bis-metallic reagents with anionic systems.

Experimental Section

General procedures. Proton chemical shifts are reported in parts per million (ppm) relative to $CDCl_3$. Infrared spectra are reported in cm^{-1}. Analytical GC measurements were performed using a 25-m cross-linked 5% methylphenylsilicon capillary column. Ether and THF were distilled immediately before use under a nitrogen atmosphere from sodium/benzophenone ketyl. Thiophene, benzothiophene, 1- and 2-bromopyridine, *N,O*-bis(trimethylsilyl)hydroxylamine (**1**), and CuCN were commercially available and used without any further purification. The purity of the commercially available *n*-BuLi, *s*-BuLi, *t*-BuLi and PhLi was checked according to Gilman.[25]

Unless otherwise stated, the HO lithium cyanocuprates were prepared according to the following general procedure: CuCN (2.00 mmol) was added to a dry 25-mL round-bottom flask equipped with a stirring bar and a rubber septum under nitrogen. THF (8 mL) was injected, the slurry was cooled to −78 °C, and the lithium compound (4.00 mmol) was added dropwise. Then the temperature was allowed to rise until the reaction mixture became clear (ca. −50 °C).

(25) Gilman, H.; Haubein, A. H. *J. Am. Chem. Soc.* **1944**, *66*, 1515.

Aniline (3a). To the brown clear solution of $Ph_2CuCNLi_2$ (2.00 mmol), cooled to −50 °C, was added 0.426 mL (2.00 mmol) of **1** dropwise. After 1 h, the dark mixture was hydrolyzed with 30 mL of 20% aqueous HCl solution. The aqueous layer was made basic with NaOH, and the free aniline was extracted twice with 20 mL of ether. The organic layer was washed with brine and dried over Na_2SO_4. The solution was concentrated *in vacuo* to give an oil which was purified by distillation to give 0.167 g (90%) of aniline as a clear liquid (bp 92 °C/30 mmHg) whose spectral data matched those of authentic material: ^{1}H NMR (200 MHz, $CDCl_3$) δ 7.0–7.5 (m, 5H,C_3H_5), 3.2–3.9 (br, 2H, NH_2); MS *m/z* (relative intensity) 93 (M^+, 100), 65 (20), 66 (40).

4-Methoxyaniline (3b). To a brown solution of (*p*-Me$OC_6H_4)_2CuCNLi_2$ (2.00 mmol) from 4-lithioanisole[26] and CuCN, cooled to −50 °C, was added 0.426 mL of **1** dropwise. After 1 h, the dark mixture was hydrolyzed with 30 mL of 20% HCl. From the aqueous layer basified with NaOH the free amine was extracted twice with 20 mL of ether. The organic layer was washed with brine and dried over Na_2SO_4. The solution was evaporated to give 0.172 g (70%) of a pale yellow solid (mp 56–59 °C) whose spectral data were identical to those of the commercial product: ^{1}H NMR (200 MHz, $CDCl_3$) δ 6.6–6.8 (d, 4H, C_6H_4), 3.74 (s, 3H, OCH_3), 3.3–3.5 (br, 2H, NH_2); MS *m/z* (relative intensity) 123 (M^+, 5), 122 (58), 107 (100), 79 (40).

2-[(Trimethylsilyl)amino]thiophene (3c). To a solution of (2-Th)$_2CuCNLi_2$ (2.00 mmol) in THF (6 mL), cooled to −50 °C, was added 0.426 mL of **1** dropwise. After 1 h the reaction mixture was warmed to rt, was filtered through a Celite pad, and was evaporated *in vacuo* to give a dark oily residue. The crude product was purified by distillation (bp 38–40 °C/0.3 mmHg) to afford 0.246 g (72%) of a colorless liquid that slowly darkens on exposure to light: ^{1}H NMR (200 MHz, $CDCl_3$) δ 6.09–6.75 (m, 3H, C_4SH_3), 3.65 (br, 1H, NH), 0.29 (s, 9H, $SiMe_3$); ^{13}C NMR (50.3 MHz, $CDCl_3$) δ 152.0, 126.1, 111.5, 108.3, 0.3; MS *m/z* (relative intensity) 171 (M^+ 24), 170 (83), 154 (77), 128 (85), 73 (100). Anal. Calcd for $C_7H_{13}NSSi$: C, 49.17; H, 7.65; N, 8.18. Found: C, 48.95; H, 7.53; N, 8.15.

2-Aminobenzo[*b*]thiophene (3d). The experimental procedure was the same as that followed for the synthesis of the thiophene derivative **3c**. The reaction mixture, filtered through a Celite pad, was evaporated under vacuum to give crude material which, on purification by flash chromatography (SiO_2, 0–100% hexane–ethyl acetate gradient elution), afforded 0.172 g (58%) of a colorless solid (mp 115–116 °C): ^{1}H NMR (200 MHz, $CDCl_3$) δ 7.58 (m, 1H), 7.43 (m, 1H), 7.25 (m, 1H), 7.13 (m, 1H), 6.28 (s, 1H), 4.05 (br, 2H, NH_2); ^{13}C NMR (50.3 MHz, $CDCl_3$) δ 150.4, 140.8, 133.2, 124.6, 121.7, 121.6, 120.8, 102.1; MS *m/z* (relative intensity) 149 (M^+, 54), 121 (68), 120 (100), 77 (49), 76 (29), 68 (23). Anal. Calcd for C_8H_7NS: C, 64.40; H, 4.73; N, 9.39. Found: C, 64.9; H, 4.68; N, 9.28. Benzo[*b*]thiophene (0.32 g) detected by GC–MS of the crude prior to hydrolytic workup was also isolated by flash chromatography.

2-Aminopyridine (3e). *n*-Butyllithium 2.5 M (2.00 mmol) in hexane was added to 10 mL of THF cooled to below 0 °C. The solution was cooled to −100 °C, and 0.388 mL (4.00 mmol) of 2-bromopyridine was added dropwise over 15 min with magnetic stirring under nitrogen atmosphere. During this time the temperature was kept at −100 °C and then allowed to rise to −80 °C, and the reaction mixture was kept at this temperature for 2 additional h. Then 0.178 g (2.00 mmol) of CuCN was added to the deep orange solution. After an additional 0.5 h the temperature was allowed to rise −60 °C, and 0.426 mL of **1** was added. The reaction mixture was filtered through a Celite pad and evaporated under vacuum to give a brown oil that was purified by flash chromatography (SiO_2, 0–100% hexane–ethyl acetate gradient elution), affording 0.110 g (60%) of a white solid (mp 58–60 °C), whose analytical data matched that of an authentic sample: ^{1}H NMR (200 MHz, $CDCl_3$) δ 8.3–6.4 (m, 4H, C_6NH_4), 5.6–4.3 (br, 2H, NH_2); MS *m/z* (relative intensity) 94 (M^+, 100), 67 (85), 66 (20).

3-Aminopyridine (3f). The experimental procedure was the same as that used for the synthesis of 2-aminopyridine. After the usual workup 0.108 g (58%) of a white solid (mp 57–59 °C) was obtained whose spectral data were identical to those of an authentic sample: ^{1}H NMR (200 MHz, $CDCl_3$) δ 8.3–7.0 (m, 4H, C_4NH_4), 4.5–3.7 (br, 2H, NH_2); MS *m/z* (relative intensity) 94 (M^+, 100), 67 (85), 66 (30).

2-[(Trimethylsilyl)imino]-2(3*H*)-benzofuranone (3g). A mixture of 10 mL of dry THF and 0.432 g (4.00 mmol) of benzofuran was cooled to −20 °C, and 1.6 mL (4.00 mmol) of a 2.5 M solution of *n*-BuLi in hexane was added. The reaction mixture was warmed to rt with stirring. The solution was then cooled to −40 °C, and 0.179 g (2 mmol) of CuCN was added. Warming to ca. −30 °C gave a clear solution to which after 30 min was added 0.430 mL (2 mmol) of **1**. The reaction mixture was allowed to reach rt overnight and was quenched with trimethylchlorosilane (0.9 mL, 7 mmol).[27] Removal of the solvent under vacuum followed by Kugelrohr distillation of the dark oily residue (pot temperature, 100 °C/0.03 mmHg) gave 0.287 g (70%) of **3g** as a pale yellow oil: ^{1}H NMR (200 MHz, $CDCl_3$) δ 7.39–6.8 (m, 4H, Ar), 3.69 (s, 2H, CH_2), 0.35 (s, 9H, $SiMe_3$); ^{13}C NMR (50.3 MHz, $CDCl_3$) δ 153.2, 129.5, 129.3, 121.6, 121.1, 118.4, 19.0, 0.4; HRMS (EI$^+$) calcd for $C_{11}H_{15}NOSi$ 205.09229, found 205.09153.

***N*-*n*-Butylbenzamide.** To a clear solution of (*n*-Bu)$_2CuCNLi_2$ (2.00 mmol), cooled to −50 °C, was added 0.426 mL of **1** dropwise with stirring under nitrogen. After 1 h the reaction mixture was allowed to warm to rt, and then at 0 °C 0.7 mL (6.00 mmol) of benzoyl chloride and 0.5 mL (6.00 mmol) of pyridine were added dropwise with stirring. The reaction mixture was kept overnight at rt. The black mixture was evaporated under vacuum, ether was added, and the solution was treated with 6 N HCl. The organic layer was washed with 5% NaOH, twice with brine and dried over Na_2SO_4. The crude material obtained after evaporation of the solvent was purified by flash chromatography (SiO_2, hexane–ethyl acetate (1:2)) to give 0.171 g (48%) of a pale yellow solid whose analytical data matched those of an authentic sample: ^{1}H NMR (200 MHz, $CDCl_3$) δ 7.8–7.3 (m, 5H, C_6H_5), 6.6 (br, 1H, NH), 3.5–3.3 (m, 2H, CH_2), 1.7–1.3 (m, 4H, CH_2CH_2), 1–0.8 (t, 3H, CH_3, J = 7.3 Hz); IR ($CDCl_3$, cm^{-1}) 3450 (s), 3000 (s), 2875 (s), 1650 (s), 1585 (m), 1250 (s), 1150 (w); MS *m/z* (relative intensity) 177 (M^+, 6), 176 (46), 134 (42), 133 (55), 105 (25), 104 (100), 77 (13), 76 (97), 51 (60).

***N*-*sec*-Butylbenzamide.** The experimental procedure was the same as that followed for the synthesis of the *n*-butyl derivative. A white solid (0.212 g, 60%) was obtained whose analytical data matched that of an authentic sample: ^{1}H NMR (200 MHz, $CDCl_3$) δ 8.2–7.7 (m, 5H, C_6H_5), 6.15 (br, 1H, NH), 4.1 (m, 1H, CH), 1.55 (m, 2H, CH_2), 1.2 (d, 3H, CH_3, J = 6.6 Hz), 0.9 (t, 3H, CH_3, J = 7.2 Hz); IR ($CDCl_3$, cm^{-1}) 3300 (m), 3050 (w), 2975 (m), 1640 (m), 1450 (m), 1215 (m); MS *m/z* (relative intensity) 177 (M^+, 10), 176 (52), 147 (18), 146 (55), 121 (31), 105 (35), 104 (100), 77 (18), 76 (71), 51 (59).

***N*-*tert*-Butylbenzamide.** The experimental procedure was the same as that followed for the synthesis of the *n*-butyl derivative. A white solid (0.280 g, 80%) was obtained whose analytical data matched those of an authentic sample: ^{1}H NMR (200 MHz, $CDCl_3$) δ 8.2–7.6 (m, 5H, C_6H_5), 5.95 (br, 1H, NH), 1.45 (s, 9H, $(CH_3)_3$); IR ($CDCl_3$, cm^{-1}) 3450 (m), 2975 (s), 1650 (s), 1575 (m), 1525 (s), 1225 (s); MS *m/z* (relative intensity) 177 (M^+, 7), 176 (52), 161 (33), 121 (44), 105 (22), 104 (100), 77 (18), 76 (85), 51 (47).

***n*-Butyl, *sec*-Butyl, and *tert*-Butyl Benzoates.** The analysis of the benzoates derived from the corresponding alcohols was performed by GC and GC/MS directly on the reaction mixture from which the benzamides were isolated before treating with 6 N HCl. Quantitative evaluation was carried out using a calibration scale made with authentic samples.

Acknowledgment. Financial support by the Italian Progetto Finalizzato Chimica Fine II (CNR, Rome) is acknowledged.

(26) Brandsma, L.; Verkruijsse, H. D. *Preparative Polar Organometallic Chemistry*; Springer: Heidelberg, 1986; Vol. 1.

(27) A beneficial effect of adding Me_3SiCl to the reaction mixture before isolation of **3g**, avoiding hydrolytic workup, has been observed; the generality of this effect is now being investigated.