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A New Method of α-Functionalization for Tertiary Amines by Nucleophilic Substitution of α-Siloxy Amines

Norihiro Tokitoh† and Renji Okazaki*
Department of Chemistry, Faculty of Science, The University of Tokyo,
Hongo, Bunkyo-ku, Tokyo 113
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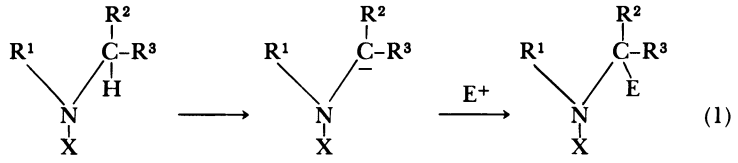
α-Siloxy amines, which were easily prepared by "silicon Polonovski reaction" of tertiary amine *N*-oxides with trialkylsilyl trifluoromethanesulfonate, were treated with various nucleophiles to give the corresponding α-functionalized tertiary amines in moderate to good yields. This new method has the advantage that it enables the α-substitution of amines not only by alkyl groups but also by alkenyl and aryl groups with sp^2 carbon as a reaction center, since the introduction of such groups is difficult in electrophilic substitution of dipole-stabilized α-lithio amines. Besides the organometallics such as Grignard and organoaluminum reagents, trimethylsilyl cyanide and silyl enol ether could also be employed as nucleophiles in the presence of an appropriate Lewis acid.

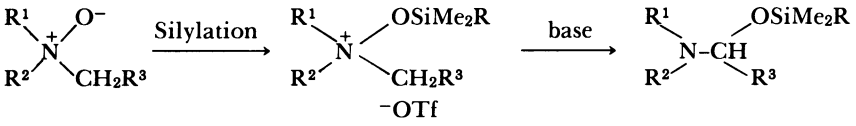
The carbon–carbon bond formation at the α-position of amines is one of the most important problems in the syntheses of nitrogen-containing natural products such as alkaloids. Although the electrophilic α-substitution methods have been developed extensively in recent years using dipole-stabilized α-lithio amines[1] as shown in Eq. 1, all of them are only applicable to secondary amine



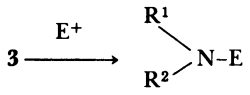
(1)

X=NO, COR, CH=N-Bu^t, etc.

derivatives and there are very few reports on the direct generation of α-carbanion of tertiary amines.[2] On the other hand, the conventional Mannich type of nucleophilic introduction of α-substituents into primary and secondary amines[3] have been studied widely but direct α-functionalization of tertiary amines has not been fully investigated. We have recently reported a facile formation of α-siloxy amines **3** ("silicon Polonovski reaction") by the base-promoted rearrangement of siloxyammonium salts **2** obtained by treatment of tertiary amine *N*-oxides **1** with trialkylsilyl trifluoromethanesulfonate and their reactions with some electrophiles (Eq. 2).[4]

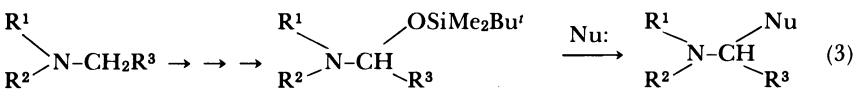


1 **2** **3**



(2)

As an extension of the above reactions we have examined nucleophilic substitutions of the siloxyl group of **3** in the hope of the development of a new and general nucleophilic α-functionalization method for tertiary amines (Eq. 3).[5]



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† Present address; Department of Chemistry, University of Tsukuba, Tsukuba, Ibaraki 305.

Results and Discussion

Nucleophilic Substitution with Organometallics.

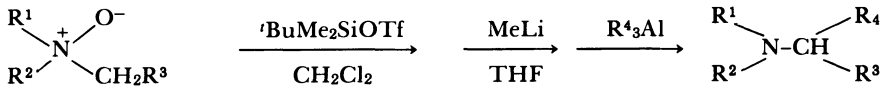
a) Reactions with Grignard Reagents. The reactions of α-siloxy amines **3** with Grignard reagents as nucleophiles were examined. In the case of *N*-methylpiperidine *N*-oxide (**1a**), treatment of the corresponding α-siloxy amine **3a** obtained in situ from **1a** with several Grignard reagents afforded the expected α-substituted products **4a** in moderate to good yields when the solvent was replaced by toluene before the reaction with the Grignard reagents. These results are given in Table 1.

When the Grignard reagent was added without the solvent exchange into toluene, the yield of **4a** was somewhat diminished (Entry 1).

This α-substitution reaction was applied to the introduction of substituents into the 1-position of tetrahydroisoquinoline skeleton which is important in the alkaloid synthesis using *N*-methyl-1,2,3,4-tetrahydroisoquinoline *N*-oxide (**1b**) as a substrate. In this case the addition of Lewis acid before that of the Grignard reagent was necessary in contrast to the reaction of **1a**. The results listed in Table 2 show that the substitution proceeded most effectively when α-siloxy amine **3b** was treated with trimethylsilyl trifluoromethanesulfonate (TMSOTf).

When this reaction was carried out in the absence of Lewis acid, the yield and reproducibility in the formation of **4b** became poorer.

b) Reactions with Trialkylaluminums. Substitution of the siloxyl group in **3** with trialkylaluminums was next examined.[6] The results obtained from the reactions of several amine *N*-oxides are given in Table 3 and in all cases the expected α-substitution products



4 were obtained in moderate to good yields. In contrast to the substitution reaction by Grignard reagents mentioned above, organoaluminum reagents gave the α-substitution products **4** in good yields without the solvent exchange into toluene before the addition of the orgnometallics except in the case of **1b**, where the α-substitution product **4b** was obtained only in 20% yield using dichloromethane as a solvent in the last step.[7]

Table 1. α-Substitution of **1a** with Grignard Reagents

Entry	Grignard reagent	Solvent	Yield of **4a**/%
1	PhMgBr	THF	58
2	PhMgBr	Toluene	74(80)[a]
3	CH_2=CHMgBr	Toluene	51
4	$PhCH_2MgBr$	Toluene	52(71)[a]
5	CH_3CH_2MgBr	Toluene	47

a) Values in parentheses denote NMR yields.

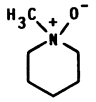
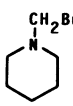
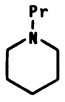
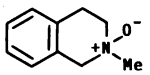
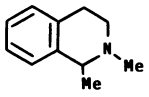
Table 2. α-Substitution of **1b** with Grignard Reagents

Entry	Lewis acid	RMgX	Solvent	Yield/%
1	$TiCl_4$	PhMgBr/THF	Toluene	27
2	$BF_3 \cdot Et_2O$	PhMgBr/THF	Toluene	17
3	Me_3SiOTf	PhMgBr/THF	Toluene	56
4	Me_3SiOTf	CH_3CH_2MgBr/THF	Toluene	41
5	Me_3SiOTf	CH_2=CHMgBr/THF	Toluene	54
6	Me_3SiOTf	$PhCH_2MgBr$/THF	Toluene	11
7	Me_3SiOTf	CH_3MgI/Et_2O	THF-Et_2O (1:2)	29

Reactions with Other Nucleophiles. Lewis Acid-Promoted Nucleophilic Substitution of α-Siloxy Amines. Since the Lewis acidity of the organometallics seemed to play an important role in the above-mentioned nucleophilic substitution of α-siloxy amines **3** with organometallics, some attempts were made to extend this substitution to some other nucleophiles by use of an appropriate Lewis acid.

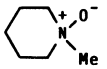
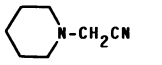
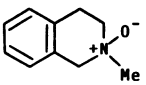
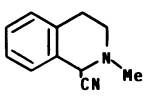
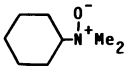
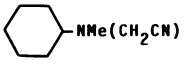
a) Reactions with Trimethylsilyl Cyanide; a New Synthesis of α-Cyano Amines.[8] When the α-siloxy amines **3** obtained in situ from the corresponding amine *N*-oxides **1** were treated with titanium tetrachloride and trimethylsilyl cyanide after replacement of the solvent into dichloromethane, the α-cyanated products **5** were obtained in good yields. As a Lewis acid titanium tetrachloride was most effective; trimethylsilyl trifluoromethanesulfonate (TMSOTf) and tin(IV) chloride could also be used but the yields of **5** were somewhat diminished. Results obtained from the reactions of several amine *N*-oxides are summarized in Table 4. The results suggest that, as in the dealkylation of tertiary amines via α-siloxy amines **3**,[4] the regioselectivity of this cyanation is controlled by the acidity of the α-hydrogen of substituents on the ammonium salt **2** which is deprotonated by the base. Thus, **1a** and *N,N*-dimethylcyclohexylamine oxide (**1d**) were cyanated at the methyl group and **1b** at the benzyl group exclusively, while *N,N*-dimethylbenzylamine oxide (**1e**) gave two regioisomers (**5e** and **5e'**). It appears that the deprotonation of the methyl group in

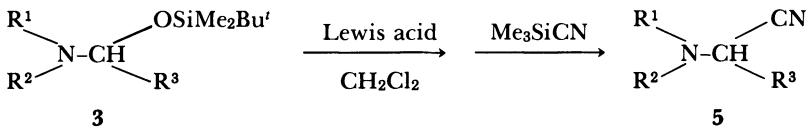
Table 3. α-Substitution by Organoaluminum Reagents

Entry	*N*-Oxide **1**		R_3Al	Yield of **4**	
1		**1a**	*i*-Bu_3Al		45
2	**1a**		Et_3Al		69(91)[a]
3		**1b**	Me_3Al		20
4	$(PhCH_2)_3N^+-O^-$	**1c**	Et_3Al	$(PhCH_2)_2NCH(Et)Ph$	75

a) Values in parentheses denote NMR yields.

Table 4. α-Cyanation of Tertiary Amines via α-Siloxy Amines

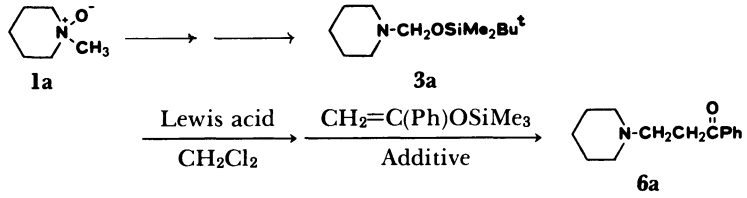
Entry	*N*-Oxide **1**		Lewis acid	Product **5**		Yield/%
1		**1a**	$TiCl_4$		**5a**	61
2		**1b**	$TiCl_4$		**5b**	63
3	**1b**		Me_3SiOTf	**5b**		24
4	**1b**		$SnCl_4$	**5b**		17
5	$(PhCH_2)_3N^+-O^-$	**1c**	$TiCl_4$	$(PhCH_2)_2NCH(CN)Ph$	**5c**	78
6		**1d**	$TiCl_4$		**5d**	71
7	$PhCH_2(Me)_2N^+-O^-$	**1e**	$TiCl_4$	$PhCH(CN)NMe_2$ $PhCH_2NMe(CH_2CN)$	**5e** **5e'**	22 40



3 5

the reactions with **1a** and **1d** predominates over that of the methylene and methine groups but the preference between methyl and benzyl groups in the deprotonation depends on the structure of the *N*-oxides (**1e** vs. **1b**). In the absence of Lewis acids this cyanation did not proceed in contrast to the reactions with Grignard and organoaluminum reagents.

b) Reactions with Silyl Enol Ether. As another application of this Lewis acid promoted substitution reaction of α-siloxy amines, reactions with a silyl enol ether were examined. Thus, **1a** was converted into the corresponding α-siloxy amine **3a** and then after replacement of the solvent into dichloromethane **3a** was treated with α-trimethylsiloxystyrene in the presence of some kinds of Lewis acids. The results are given in Table 5. As a Lewis acid TMSOTf was most effective; with other Lewis acids the yiels of **6a** were much lower and the reaction became complicated. In this sustitution the addition of fluoride ion resulted in improvement of the yield (Run 4).



1a 3a 6a

In summary we have established a new and convenient α-substitution method for teriary amines not only by simple alkyl groups but also by alkenyl, aryl, cyano, and β-oxoalkyl groups using α-siloxy amines. In view of ready availability of amine *N*-oxides and nucleophiles and a wide variety of the synthetic application of this α-functionalization method described here, we believe that this type of transformation reaction of tertiary amines will provide a new methodology in organic synthesis, especially in the syntheses of nitrogen-containing natural products.

Experimental

All the melting points and boiling points were not corrected. ^{1}H NMR spectra were measured with Hitachi R-24B, Hitachi R-20B (60 MHz), and JEOL JNM-FX90Q (90 MHz) spectrometers using tetramethylsilane as an internal standard. ^{13}C NMR spectra were measured with a JEOL JNM-FX90Q (90 MHz) spectrometer. The NMR spectra were measured in deuteriochloroform at room temperature unless otherwise noted. MS spectra were measured with a JEOL JMS-D300 mass spectrometer. All the experiments were carried out in argon or nitrogen atmosphere. Chromatographic separation was carried out with hexane–ether as solvent. Isolated products were homogeneous in thin layer chromatography and their NMR spectra did not show the presence of impurity.

Table 5. Reactions of **3a** with α-Trimethylsiloxystyrene

Run	Lewis acid	Additive	Yield of **6a**/%
1	$TiCl_4$	—	13
2	$Ti(O\text{-}i\text{-}Pr)_4$	—	6
3	Me_3SiOTf	—	39
4	Me_3SiOTf	KF	47

Materials. Amine *N*-oxides were prepared by oxidation of the corresponding amines by either 30% hydrogen peroxide or m-chloroperbenzoic acid. *N*-Methyl-1,2,3,4-tetrahydroisoquinoline[9] and *N*-benzylpiperidine[10] were prepared by the reported method. The other amines used were commercial products.

Reactions with Grignard Reagents. Reaction of *N*-Methylpiperidine *N*-Oxide (1a). The procedure with phenylmagnesium bromide is typical.

General Procedure. Transformation of 1a into *N*-Benzylpiperidine (4a). To a solution of **1a** (120.7 mg, 1.05 mmol) in 10 ml of dichloromethane was added TBDMSOTf (291 mg, 1.05 equiv), the solvent was carefully removed with a vacuum pump and then THF (10 ml) and MeLi (1.2 mmol, 1.1 equiv) were added at 0 °C. After further replacement of the solvent by toluene (10 ml) in a similar way, phenylmagnesium bromide (1.58 mmol, 1.5 equiv) was added at 0 °C and the mixture was stirred overnight at room temperature. After evaporation of the solvent the mixture was shaken with 50 ml of 5% aq NaOH solution and 50 ml of dichloromethane and the aqueous layer was extracted with dichloromethane (30 ml×3). The extracts and the organic layer were combined, dried over $MgSO_4$, and concentrated. The ^{1}H NMR spectrum of the resulting crude oil showed the exclusive formation of the expected *N*-benzylpiperidine (**4a**; R=Ph) and *t*-butyldimethylsilanol and the NMR yield of **4a** (R=Ph) was estimated 80%. Chromatography of the crude oil on alumina afforded **4a** (R=Ph) in 74% yield (136.4 mg) as a colorless oil.

Other reactions of **1a** listed in Table 1 were carried out in a similar way to the above-mentioned reaction with phenylmagnesium bromide to give the corresponding α-substituted products (**4a**; R=CH=CH_2, CH_2Ph, and CH_2CH_3) in 51, 52,

and 47% yields, respectively.

4a, R=CH=CH$_2$: ^{1}H NMR δ=1.2—2.1 (m, 6H), 2.3—2.7 (m, 4H), 2.9—3.1 (m, 2H), and 4.9—6.7 (m, 3H); MS, *m/z* 125 (M$^+$, 5%), 124 (8), 108 (6), 98 (15), 88 (52), and 75 (100); pale yellow oil.[11]

4a, R=CH$_2$Ph: ^{1}H NMR δ=1.0—2.0 (m, 6H), 2.0—2.7 (m, 4H), 2.2—3.1 (m, 4H), and 7.31 (s, 5H); MS, *m/z* 190 (2%), 189 (M$^+$, 6), 188 (3), 149 (3), 105 (23), 99 (38), 98 (100), 91 (9), and 77 (15); pale yellow oil.[12]

4a, R=CH$_2$CH$_3$: ^{1}H NMR δ=0.8—1.7 (m, 11H), and 2.0-2.5 (m, 6H); ^{13}C NMR δ=61.68, 54.74, 26.14, 24.65, 20.15, and 12.11; colorless oil.[13]

Reactions with *N*-Methyl-1,2,3,4-tetrahydroisoquinoline *N*-Oxide (1b). As a typical example of the reactions of **1b**, the procedure with phenylmagnesium bromide and trimethylsilyl trifluoromethanesulfonate is described.

Transformation of 1b to 4b. To a solution of *N*-oxide **1b** (130 mg, 0.8 mmol) in 10 ml of dichloromethane was added TBDMSOTf (232 mg, 1.1 equiv) and after the solvent exchange into THF (10 ml) was added MeLi (0.96 mmol, 1.2 equiv) at 0 °C. After replacement of the solvent into toluene (10 ml) was added MeLi (0.96 mmol, 1.2 equiv) at 0 °C. After the solvent was exchanged into toluene (10 ml) was added trimethylsilyl trifluoromethanesulfonate (TMSOTf) (213 mg, 1.2 equiv) at −78 °C and the mixture was warmed to room temperature with stirring. Phenylmagnesium bromide (1.2 mmol, 1.5 equiv) was then added to this mixture at 0 °C and the mixture was warmed to 70 °C with stirring for 24 h. It was then shaken with 50 ml of 5% aq NaOH solution and 50 ml of ether, and the aqueous layer was extracted with dichloromethane (30 ml×3). The extracts and organic layer were combined, dried over MgSO$_4$, and concentrated. Chromatography of the residual oil on alumina gave the α-phenylated product (**4b**, R=Ph) (100.2 mg, 56%) as a pale yellow solid.

4b, R=Ph: ^{1}H NMR δ=2.21 (s, 3H), 2.3—3.8 (m, 4H), 4.24 (brs, 1H), 6.5—7.5 (m, 4H), and 7.27 (s, 5H); MS, *m/z* 223 (M$^+$, 19%), 222 (15), 179 (17), 178 (10), 165 (6), 147 (22), 146 (100), 131 (6), 118 (2), 103 (2), 91 (5), and 77 (5); high-MS, *m/z* Found 223.1381, Calcd for C$_{16}$H$_{17}$N: 223.1361; mp 69—70 °C (lit,[14] 72 °C).

The other reaction of **1b** listed in Table 2 were carried out similarly to give the corresponding α-substitution products. In the case of the reaction with methylmagnesium iodide (Entry 7) the yield of **4b** (R=Me) decreased to 15% when toluene was used as a solvent instead of a mixed solvent (THF-ether=1:2).

4b, R=CH$_2$CH$_3$: ^{1}H NMR δ=0.84 (t, *J*=7 Hz, 3H), 1.5—2.1 (m, 2H), 2.33 (s, 3H), 2.4—3.6 (m, 5H), and 7.09 (s, 4H), MS, *m/z* 175 (M$^+$, 2%), 174 (28), 147 (9), 146 (100), 131 (4), 115 (2), 91 (2), and 77 (2); high-MS, *m/z* Found 175.1354, Calcd for C$_{12}$H$_{17}$N: 175.1360; pale yellow oil.

4b, R=CH=CH$_2$: ^{1}H NMR δ=2.1—3.4 (m, 4H), 2.39 (s, 3H), 3.70 (d, *J*=7.5 Hz, 1H), 4.9—6.1 (m, 3H), and 7.09 (s, 4H); MS, *m/z* 173 (M$^+$, 6%), 172 (7), 146 (55), 119 (13), 118 (100), 91 (20), 90 (46), 77 (13), 71 (39), and 57 (45); high-MS, *m/z* found 173.1205, Calcd for C$_{12}$H$_{15}$N: 173.1205; yellow oil.

4b, R=CH$_2$Ph: ^{1}H NMR δ=2.46 (s, 3H), 2.7—3.6 (m, 6H), 3.84 (t, *J*=6 Hz, 1H), and 7.0—7.5 (m, 9H); MS, *m/z* 237 (M$^+$, 8%), 236 (26), 234 (29), 160 (7), 147 (7), 146 (100), 145 (16), 144 (58), 131 (19), 105 (18), 91 (36), and 77 (15); high-MS, *m/z* Found 237.1467, Calcd for C$_{17}$H$_{19}$N: 237.1517; yellow oil.

4b, R=CH$_3$: ^{1}H NMR δ=1.39 (d, *J*=7 Hz, 3H), 2.48 (s, 3H), 2.4—3.7 (m, 5H), and 7.0-7.3 (m, 4H); MS, *m/z* 161 (M$^+$, 7%), 160 (5), 146 (20), 147 (100), 144 (7), 131 (8), 118 (12), 114 (17), 91 (6), and 77 (7); yellow oil.[15]

Reactions with Trialkylaluminums; α-Substitution of 1a by Triisobutylaluminum. To a solution of **1a** (165.6 mg, 1.44 mmol) in 10 ml of dichloromethane was added TBDMSOTf (424 mg, 1.1 equiv) and after the solvent exchange into THF (10 ml) was added MeLi (1.73 mmol, 1.2 equiv) at 0 °C. To this solution was added triisobutylaluminum (1.73 mmol, 1.2 equiv in 15% hexane solution) at −78 °C and then the mixture was warmed to room temperature with stirring. After stirring for 14 h, the solvent was evaporated and the resulting oil was subjected to chromatography (alumina, hexane-ether=5:2) to give *N*-isopentylpiperidine (**4a**; R=*i*-Bu)(100 mg, 45%) as a colorless oil.[16]

4a, R=*i*-Bu: ^{1}H NMR δ=0.7—1.1 (m, 6H), 1.1—2.0 (m, 9H), and 2.0—2.6 (m, 6H); MS, *m/z* 155 (M$^+$, 8%), 154 (1), 110 (4), 99 (9), 98 (100), 85 (4), 84 (4), 71 (5), and 57 (8).

Reactions of Other *N*-Oxides with Trialkylaluminums. Reactions of **1a** and **1c** with triethylaluminum were carried out similarly to the above-mentioned α-isobutylation to afford the corresponding α-ethylated products (**4a**, R=CH$_2$CH$_3$) and (**4c**, R=CH$_2$CH$_3$) in 69 and 75% yields, respectively. α-Methylation of **1b** with trimethylaluminum was carried out in dichloromethane instead of THF to give the α-methylated product (**4b**, R=CH$_3$) in 20% yield.

4c, R=CH$_2$CH$_3$: ^{1}H NMR δ=0.9 (t, *J*=8 Hz, 3H), 1.5—2.3 (m, 2H), 3.48 (ABq, δ_{AB}=0.42, J_{AB}=14 Hz, 4H), 3.59 (t, *J*=8 Hz, 1H), and 7.0—7.6 (m, 15H); ^{13}C NMR δ=140.44, 139.17, 128.96, 128.74, 127.88, 126.68, 64.01, 53.82, 24.30, and 11.67; MS, *m/z* 315 (M$^+$, 1%), 287 (13), 286 (46), 210 (3), 194 (8), 181 (5), 118 (4), 92 (9), 91 (100), and 65 (8); high-MS, *m/z* Found 315.1962, Calcd for C$_{23}$N$_{25}$N: 315.1987; yellow oil.

α-Cyanation. As a typical example of α-cyanations, the procedure with **1b** is described. Transformation of **1b** into **5b**. To a solution of **1b** (156 mg, 0.96 mmol) in 10 ml of dichloromethane was added TBDMSOTf (279 mg, 1.1 equiv) and after replacement of the solvent by THF (10 ml) was added MeLi (1.15 mmol, 1.2equiv) at 0 °C. After the solvent was again exchanged into dichloromethane (10 ml), titanium tetrachloride (237 mg, 1.3 equiv) was added at −78 °C and the mixture was stirred for 1 h at this temperature. To the greenish-brown suspension was then added trimethylsilyl cyanide (0.19 ml, 1.5 equiv) at −78 °C. After stirring overnight at room temperature, the mixture was shaken with 50 ml of 5% aq NaOH solution and 50 ml of dichloromethane, and the aqueous layer was extracted with dichloromethan (30 ml×3). The extracts and organic layer were combined, dried over MgSO$_4$, and concentrated. Chromatography of the residual oil gave 1-cyano-*N*-methyl-1,2,3,4-tetrahydroisoquinoline (**5b**) (103.9 mg, 63%) as a pale yellow solid.

5b: ^{1}H NMR δ=2.5—3.3 (m, 4H), 2.58 (s, 3H), 4.70 (s, 1H), and 6.9—7.3 (m, 4H); ^{13}C NMR δ=133.94, 129.72, 129.39, 128.50, 127.14, 126.49, 116.53, 56.96, 48.46, and 28.44; MS, *m/z* 172 (M$^+$, 45%), 171 (43), 149 (43), 146 (31), 145 (38), 144 (100), 129 (99), and 57 (27); high-MS, *m/z* Found 172.0999, Calcd for C$_{11}$H$_{12}$N$_2$: 172.0999; mp 75—77 °C (lit,[17] 76—78 °C).

The other reactions listed in Table 4 were carried out similarly to the above procedure to give the corresponding

α-cyano amines.

5a: ^{1}H NMR δ=1.0—2.0 (m, 6H), 2.2—2.7 (m, 4H), and 3.5 (s, 2H); ^{13}C NMR δ=114.87, 53.12, 46.89, 25.71, and 23.32; MS, *m/z* 124 (M^+, 40%), 123 (100), 98 (6), 96 (12), 83 (27), and 57 (22); high-MS, *m/z* Found 124.0973, Calcd for $C_7H_{12}N_2$: 124.0999; colorless oil.

5c: ^{1}H NMR δ=3.64 (ABq, δ_{AB}=0.5, J_{AB}=13.5 Hz,4H), 4.9 (s, 1H), and 7.0—7.7 (m, 15H); ^{13}C NMR δ=139.58, 137.71, 133.97, 128.74, 128.58, 128.17, 127.63, 126.82, 115.31, 57.32, and 54.99; MS, *m/z* 312 (M^+, 0.3%), 287 (4), 239 (2), 210 (4), 165 (12), 125 (10), 123 (28), 105 (14), 93 (33), 91 (100), and 55 (52); high-MS, *m/z* Found 312.1624, Calcd for $C_{22}H_{20}N_2$: 312.1624; white solid, mp 103—104 °C (lit,[18] 103—104 °C).

5d: ^{1}H NMR δ=0.8—2.5 (m, 11H), 2.37 (s, 3H), and 3.57 (s, 2H); ^{13}C NMR δ=115.99, 61.30, 42.44, 38.98, 29.96, 25.89, and 25.14; MS, *m/z* 152 (M^+, 10%), 110 (7), 109 (100), 96 (9), and 83 (8), high-MS, *m/z* Found 152.1304, Calcd for $C_9H_{16}N_2$: 152.1312; colorless oil.

5e: ^{1}H NMR δ=2.31 (s, 6H), 4.9 (s, 1H), and 7.1—8.0 (m, 5H); MS, *m/z* 160 (M^+, 50%), 159 (16), 116 (29), 92 (29), 91 (100), and 83 (95); high-MS, *m/z* Found 116.1007, Calcd for $C_{10}H_{12}N_2$: 160.1001; colorless oil.

5e′: ^{1}H NMR δ=2.35 (s, 3H), 3.38 (s, 2H), 3.55 (s, 2H), and 7.38 (s, 5H); ^{13}C NMR δ=137.09, 128.96, 128.58, 127.78, 114.52, 60.16, 44.18, and 42.23; MS, *m/z* 160 (M^+, 39), 159 (13), 118 (3), 92 (34), 91 (100), and 83 (44); high-MS, *m/z* Found 160.1000, Calcd for $C_{10}H_{12}N_2$: 160.1001; pale yellow oil.

Reactions with a Silyl Enol Ether. Transforation of 1a into 6a. As a typical example the procedure with **1a** in the presence of TMSOTf and potassium fluoride is described. To a solution of **1a** (134 mg, 1.17 mmol) in 10 ml of dichloromethane was added TBDMSOTf (324 mg, 1.05 equiv) and after the solvent exchange into THF (15 ml) was added MeLi (1.29 mmol, 1.1 equiv). After replacement of the solvent by dichloromethane (10 ml) TMSOTf (312 mg, 1.2 equiv) was added at 0 °C. The mixture was stirred for 2 h at room temperature and then to the mixture was added α-trimethylsiloxystyrene (270 mg, 1.2 equiv) at this temperature. After stirring for 1 h at room temperature potassium fluoride (75 mg, 1.1 equiv; dried by heating at about 100 °C in vacuo just before use) was added in one portion and the mixture was refluxed for 16 h. Then the mixture was shaken with 50 ml of 5% aq NaOH solution and 50 ml of dichloromethane, and the aqueous layer was extracted with dichloromethane (30 ml×3). The extracts were combined with the organic layer, dried over $MgSO_4$, and concentrated. Chromatography of the residual oil (alumina, ether–hexane=2:1) afforded the expected α-substituted product **6a** (120 mg, 47%) as a pale yellow oil.[19]

6a: ^{1}H NMR δ=1.2—1.7 (m, 6H), 2.4—2.6 (m, 4H), 2.6—3.3 (m, 4H), 7.3—7.7 (m, 3H), and 7.8—8.2 (m, 2H); ^{13}C NMR δ=199.36, 137.17, 132.94, 128.58, 128.07, 54.63, 54.01, 34.46, 26.03, and 24.32; MS, *m/z* 217 (M^+, 6%), 132 (7), 105 (30), 99 (8), 98 (100), 97 (33), 86 (10), 84 (16), and 77 (23).

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