Novel Nucleophilic C-C Bond-forming *tele*-Reaction of Imidazole Ring

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Reaction of 2-(1-chloro-2,2-dimethylpropyl)-1-methyl-1*H*-imidazoles with diethyl methylmalonate in the presence of NaH gave a normal S_N product, 2-[(1,1-diethoxycarbonylethyl)-2,2-dimethylpropyl]-1-methyl-1*H*-imidazole (**2a**), and two *tele*-reaction products, 5-(1,1-diethoxycarbonylethyl)-1-methyl-2-(2,2-dimethylpropyl)-1*H*-imidazole (**3a**) and *trans*-4,5-di-(1,1-diethoxycarbonylethyl)-4,5-dihydro-1-methyl-2-(2,2-dimethylpropyl)-1*H*-imidazole (**4a**) in 5, 17 and 70 % yields, respectively. The scope and mechanism of this reaction are discussed.

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Introduction.

Electrophilic substitutions of an imidazole nucleus [1] and nucleophilic substitutions *via* lithioimidazoles [2] have been well known for the preparation of imidazole compounds, and we have applied the reactions of lithioimidazoles [3] and imidazolium salts [4] to the syntheses of several pharmaceutically interesting compounds and natural products [5]. On the other hand, nucleophilic reactions on the imidazole ring have been mainly performed through the activation by quaternization of the ring [6] or introducing an electron-withdrawing group such as halogen atom(s) into the nucleus [7], other examples have been quite rare [8,9]. In the preceding paper, we reported a nucleophilic addition of amines to the imidazole ring of 2-(1-chloro-2,2-dimethylpropyl)-1-methyl-1*H*-imidazole hydrochloride (**1a**) [10]. In this paper, we would like to present the first example and a possible mechanism of a C-C bond-forming nucleophilic *tele*-reaction [11] of carbon nucleophiles with **1a** and its derivatives without any activation steps of the imidazole nucleus.

Results and Discussion.

We first examined a reaction of 2-(1-chloro-2,2-dimethylpropyl)-1-methyl-1*H*-imidazole hydrochloride (**1a**) with diethyl methylmalonate in the presence of NaH (entry 1), and it was found the use of three equivalents of the malonate and NaH gave two *tele*-reaction products, 5-(1,1-diethoxycarbonylethyl)-1-methyl-2-(2,2-dimethylpropyl)-1*H*-imidazole (**3a**) and *trans*-4,5-di(1,1-diethoxycarbonylethyl)-4,5-dihydro-1-methyl-2-(2,2-dimethylpropyl)-1*H*-imidazole (**4a**) in 67 % and 11 % yields, respectively, together with a small amount of a normal S_N product [12], 2-[1-(1,1-diethoxycarbonylethyl)-2,2-dimethylpropyl]-1-methyl-1*H*-imidazole (**2 a**). The structure of **3a** was determined by HMBC correlations, and the *trans*-orientation of the 4- and 5- substituents of **4a** was confirmed by the similarity of the ^{1}H-NMR coupling constant (3.0 Hz) of H4 - H5 in the imidazoline ring as the reported value for 4,5-di(*N,N*-dimethylamino)-1-methyl-

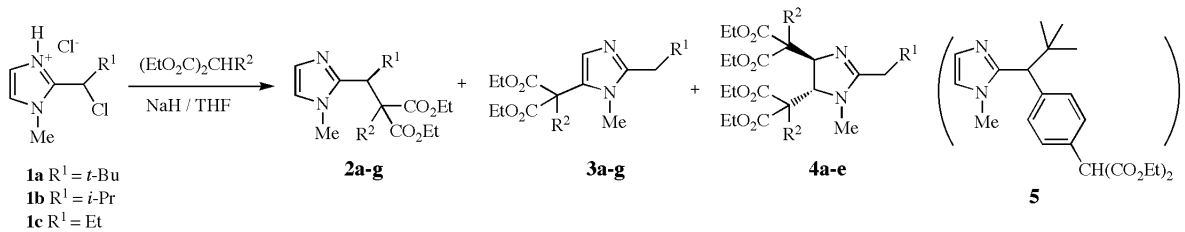
Table 1

Nucleophilic Reaction of Malonates to Imidazole Derivatives

Entry	R^1	R^2	**1** / NaH / malonate	Yield (%) (Product) **2**	**3**	**4**
1	*t*-Bu	Me	1 / 3 / 3	3 (**2a**)	67 (**3a**)	11 (**4a**)
2	*t*-Bu	Me	1 / 5 / 5	5 (**2a**)	26 (**3a**)	57 (**4a**)
3	*t*-Bu	Me	1 / 10 / 10	5 (**2a**)	17 (**3a**)	70 (**4a**)
4	*t*-Bu	Me	1 / 6.5 / 5	5 (**2a**)	34 (**3a**)	- [a]
5	*i*-Pr	Me	1 / 5 / 5	9 (**2b**)	10 (**3b**)	48 (**4b**)
6	Et	Me	1 / 3 / 3	35 (**2c**)	25 (**3c**)	30 (**4c**)
7	*t*-Bu	H	1 / 5 / 5	16 (**2d**)	61 (**3d**)	7 (**4d**)
8	*t*-Bu	Et	1 / 5 / 5	5 (**2e**)	32 (**3e**)	28 (**4e**)
9	*t*-Bu	$CH_2CH=CH_2$	1 / 5 / 5	6 (**2f**)	89 (**3f**)	- [a]
10 [b]	*t*-Bu	Ph	1 / 2 / 2	3 (**2g**)	11 (**3g**)	- [a]

[a] Not detected in the reaction mixture; [b] Unexpected S_N product **5** was also obtained in 44 %.

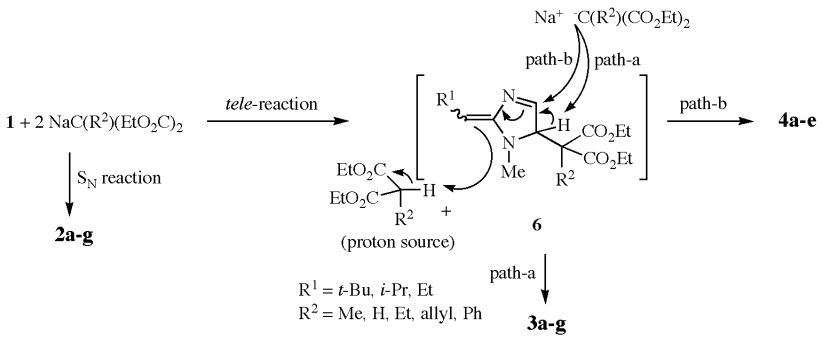
Scheme 1



2-(2,2-dimethylpropyl)-2-imidazoline (3.8 Hz) [10]. To our knowledge, this is the first example of direct nucleophilic addition of a carbon nucleophile to the imidazole ring without any electron-withdrawing substituent on the nucleus.

We considered the reaction mechanism as shown in Scheme 2. Increasing of the amount of the nucleophile decreased the yield of **3a** and increased the yield of **4a** (entries 2 and 3). In the presence of some excess of NaH over that of diethyl methylmalonate, the di-adduct **4a** was not obtained at all (entry 4) because of the absence of the proton source. This result might suggest that protonation of the intermediate **6** by diethyl methylmalonate at the side chain of the 2-position is an important factor for the formation of **4a**, and in the case of entry 4 the reaction might stop at intermediate **6**, which is converted to **3a** during work-up.

Scheme 2

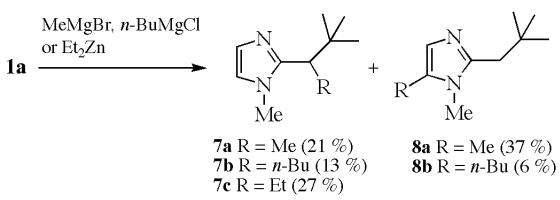


2-(1-Chloro-2-methylpropyl)-1-methyl-1*H*-imidazole hydrochloride (**1b**) was subjected to similar reaction conditions as that of entry 2 to decrease yield of the addition products **3b** and **4b** (10 and 48 %, respectively) (entry 5), and in the case of 2-(1-chloropropyl)-1-methyl-1*H*-imidazole hydrochloride (**1c**) increased yield of the S_N product **2c** (35 %) (entry 6). In entry 6, the nucleophile and the proton source can approach around the 2-position more easily than in entries 1 - 5 to increase yield of the S_N product **2c**. When the hydrochloride **1a** was treated with simple diethyl malonate instead of diethyl methylmalonate, the mono-adduct **3d** was obtained as the main product in 61 % yield together with some S_N product (**2d**, 16 %) and di-adduct (**4d**, 7 %) (entry 7). The yield of **3d** is comparable with that of **3a** in entry 1, and this indicates that the C5-H of the intermediate **6** (R^2 = Na) is abstracted by the adjacent carbanion and also the proton source [$CH_2(COOEt)_2$] can approach more easily around the 2-position of the intermediate. When the reaction of **1a** was carried out with more bulky malonate, diethyl ethylmalonate and diethyl allylmalonate than diethyl methylmalonate, yield of di-adducts was decreased very much whereas yield of mono-adducts was increased (entry 8 and 9). These results show that selectivity between path-a and path-b seems to depend mainly on the steric hindrance around C5-H of the intermediate **6** and bulkiness of the nucleophile as well as basicity of the nucleophile.

Reaction of **1a** with diethyl sodiophenylmalonate gave surprisingly an unexpected other type of *tele*-product, diethyl 4-[1-(1-methyl-1*H*-imidazol-2-yl)-2,2-dimethylpropyl]phenylmalonate (**5**), which might be raised up from an S_N reaction on the 4-position of the phenyl group of the malonate, in 44 % yield accompanied with a small amount of **2g** and **3g** (entry 10). To our knowledge, this type of unexpected nucleophilic *tele*-reaction seems to be also a very rare example in diethyl phenylmalonate [13].

Furthermore, reactions of **1a** with organometallic reagents such as alkyl Grignard reagents and dialkylzinc were examined (Scheme 3). The *tele*-substitution reactions proceeded by treatment of **1a** with five equivalents of methylmagnesium bromide or *n*-butylmagnesium chloride to give the corresponding tri-alkylated *tele*-reaction products **8a** (37 %) and **8b** (6 %) together with normal S_N products **7a** (21 %) and **7b** (13 %), respectively. This result might also show that the absence of acidic proton such as malonates in the reaction system was preferred as above-mentioned to provide the mono-adduct *via* path-a. On the other hand, the reaction of **1a** with four equivalents of diethylzinc gave only an S_N product **7c** in 27 % yield.

Scheme 3



Conclusion.

We have found a novel nucleophilic *tele*-reaction to the imidazole nucleus. Further investigations of the present reaction are currently underway.

EXPERIMENTAL

All melting points were measured with a Yanaco MP micro-melting-point apparatus and are uncorrected. The infrared spectra were taken with Shimadzu IR-435 spectrophotometer. ^{1}H nmr and ^{13}C nmr spectra were measured on Varian UNITY INOVA 400NB (^{1}H: 400 MHz, ^{13}C: 100 MHz), JEOL EX-300 (^{1}H: 300 MHz, ^{13}C: 75 MHz) or JEOL EX-270 (^{1}H: 270 MHz, ^{13}C: 68 MHz) spectrometer and the chemical shifts were expressed in parts per million downfield from tetramethylsilane as the internal standard. Mass spectra (MS) were measured on JEOL JMS BU-20 spectrometer using an electron impact mode (70 eV). Silica gel (Merck Art. 7734) for column chromatography was used.

2-(1-Chloro-2,2-dimethylpropyl)-1-methyl-1*H*-imidazole Hydrochloride (**1a**).

Thionyl chloride ($SOCl_2$, 0.73 mL, 10 mmol) was added to a stirred solution of 2-(1-hydroxy-2,2-dimethylpropyl)-1-methyl-1*H*-imidazole [3b] (840 mg, 5 mmol) in $CHCl_3$ (5 mL) under N_2 at 0 °C. After stirring for 2 h at room temperature, solvents were evaporated to give a crystalline residue, which was recrystallized from EtOH–AcOEt. The compound was obtained as a colorless powder, 961 mg (86 %), mp 168-170 °C; ir (potassium bromide): 3396, 2913, 1591, 1514, 1463 cm^{-1}; ^{1}H nmr (300 MHz, CD_3OD): δ 1.15 (9H, s), 4.00 (3H, s), 5.54 (1H, s), 7.62 (1H, d, J = 2.2 Hz), 7.66 (1H, d, J = 1.8 Hz); ^{13}C nmr (75 MHz, CD_3OD): δ 26.4 x 3, 36.3, 39.7, 59.7, 121.0, 125.4, 145.3; ms: *m/z* 188 (1.2), 186 (M^+, 3.9), 171 (5), 151 (15), 132 (32), 130 (100), 121 (13), 95 (36), 81 (11), 57 (6); Hrms Calcd. for $C_9H_{15}ClN_2$: $[M]^+$ = 186.0924. Found: 186.0933.

Anal. Calcd. for $C_9H_{15}ClN_2$: C, 48.44; H, 7.23; N, 12.55. Found: C, 48.51; H, 7.34; N, 12.24.

2-(1-Chloro-2-methylpropyl)-1-methyl-1*H*-imidazole Hydrochloride (**1b**).

n-Butyl lithium (*n*-BuLi, 1.6 *M* in *n*-hexane; 32.8 mL, 52.5 mmol) was added to a stirred solution of 1-methylimidazole (4.4 mL, 55 mmol) in THF (50 mL) under N_2 at -78 °C. After stirring for 30 min at the same temperature, 2-methylpropanal (4.54 mL, 50 mmol) was added and the resulting mixture was stirred for 2 h at ambient temperature. The mixture was then acidified with HCl aq. (10 %, 50 mL) and washed with diethyl ether (30 mL x 2). The aqueous layer was basified with K_2CO_3 powder and extracted with AcOEt (30 mL x 3). The organic layer was dried over anhydrous sodium sulfate and evaporated to give an oily residue, which was purified by recrystallized from AcOEt–*n*-hexane to give 2-(1-hydroxy-2-methylpropyl)-1-methyl-1*H*-imidazole as colorless prisms, 3.58 g (47 %), mp 77-79 °C; ir ($CHCl_3$): 3099, 2942, 1489, 1464 cm^{-1}; ^{1}H nmr (300 MHz, $CDCl_3$): δ 0.81 (3H, d, J = 6.8 Hz), 1.06 (3H, d, J = 6.6 Hz), 2.14 (1H, oct., J = 6.7 Hz), 3.67 (3H, s), 4.25 (1H, br s), 4.34 (1H, d, J = 7.9 Hz), 6.77 (1H, d, J = 1.1 Hz), 6.91 (1H, d, J = 1.3 Hz); ^{13}C nmr (75 MHz, $CDCl_3$): δ 18.6, 19.0, 32.9, 33.9, 72.3, 121.0, 126.6, 149.7; ms: *m/z* 154 (M^+, 7.4), 137 (4), 111 (100), 83 (24); Hrms Calcd. for $C_8H_{14}N_2O$: $[M^+]$ = 154.1106. Found: 154.1103.

Anal. Calcd. for $C_8H_{14}N_2O$: C, 62.31; H, 9.15; N, 18.17. Found: C, 62.12; H, 9.26; N, 17.95.

The title compound was prepared in a similar manner as that used for preparation of **1a** except for use of 2-(1-hydroxy-2-methylpropyl)-1-methyl-1*H*-imidazole instead of 2-(1-hydroxy-2,2-dimethylpropyl)-1-methyl-1*H*-imidazole. After evaporation of the solvents, the hydrochloride **(1b)** was obtained as a pale yellow crystalline residue, which was used in the next reaction without further purification; ir ($CHCl_3$): 3360, 3138, 2950, 1594, 1464 cm^{-1}; ^{1}H nmr (270 MHz, $CDCl_3$): δ 0.96 (3H, d, J = 6.6 Hz), 1.29 (3H, d, J = 6.4 Hz), 2.63-2.77 (1H, m), 3.40 (1H, br), 4.10 (3H, s), 5.34 (1H, d, J = 10.2 Hz), 7.36 (1H, d, J = 1.8 Hz), 7.63 (1H, d, J = 1.8 Hz); ^{13}C nmr (68 MHz, $CDCl_3$): δ 19.8, 20.1, 34.1, 35.8, 55.4, 118.7, 124.2, 143.5; ms: *m/z* 174 (2.8), 172 (M^+, 10), 137 (100), 132 (25), 130 (75), 121 (90), 96 (48), 81 (27); Hrms Calcd. for $C_8H_{13}ClN_2$: $[M]^+$ = 172.0767. Found: 172.0773.

2-(1-Chloropropyl)-1-methyl-1*H*-imidazole Hydrochloride (**1c**).

2-(1-Hydroxypropyl)-1-methyl-1*H*-imidazole was prepared in a similar manner as that used for preparation of 2-(1-hydroxy-2-methylpropyl)-1-methyl-1*H*-imidazole except for use of propanal instead of 2-methylpropanal. The crude product was purified by column chromatography (acetone) to give the alcohol as a yellow viscous oil, 4.41 g (63 %); ir ($CHCl_3$): 3133, 2941, 1489, 1455 cm^{-1}; ^{1}H nmr ($CDCl_3$, 400 MHz): δ 0.94 (3H, t, J = 7.4 Hz), 1.89 (2H, pent., J = 7.3 Hz), 3.69 (3H, s), 4.59 (1H, t, J = 7.0 Hz), 6.76 (1H, d, J = 1.3 Hz), 6.83 (1H, d, J = 1.3 Hz); ^{13}C nmr ($CDCl_3$, 100 MHz): δ 10.1, 28.9, 32.8, 68.1, 121.3, 126.4, 149.7; ms: *m/z* 140 (M^+, 29), 122 (36), 111 (100), 83 (51), 56 (19); Hrms Calcd. for $C_7H_{12}N_2O$: $[M]^+$ = 140.0950. Found: 140.0947.

The title compound was prepared in a similar manner as that used for preparation of **1a** except for use of 2-(1-hydroxypropyl)-1-methyl-1*H*-imidazole instead of 2-(1-hydroxy-2,2-dimethylpropyl)-1-methyl-1*H*-imidazole. After evaporation of the solvents, the crude hydrochloride **1c** was obtained as a pale yellow crystalline residue, which was purified by recrystallized from EtOH–AcOEt to give **1c** as a colorless powder, 865 mg (89 %), mp 138-140 °C; ir (potassium bromide): 3400, 2950, 2769, 1677, 1590, 1522, 1378 cm^{-1}; ^{1}H nmr (DMSO-d_6, 400 MHz): δ 1.05 (3H, t, J = 7.3 Hz), 2.38 (2H, pent., J = 7.3 Hz), 3.92 (3H, s), 5.69 (1H, t, J = 7.3 Hz), 7.72 (1H, d, J = 1.8 Hz), 7.80 (1H, d, J = 1.8 Hz); ^{13}C nmr (DMSO-d_6, 100 MHz): δ 11.1, 28.2, 34.7, 50.9, 119.9, 124.6, 143.8; ms: *m/z* 160 (2.4), 158 (M^+, 8.3), 132 (8), 130 (23), 123 (96), 107 (100), 96 (31), 81 (35), 56 (30); Hrms Calcd. for $C_7H_{11}ClN_2$: $[M]^+$ = 158.0611. Found: 158.0609.

Anal. Calcd. for $C_7H_{12}Cl_2N_2$: C, 43.10; H, 6.20; N, 14.36. Found: C, 43.38; H, 6.44; N, 14.09.

Synthesis of 2-[1-(1,1-Diethoxycarbonylethyl)-2,2-dimethylpropyl]-1-methyl-1*H*-imidazole (**2a**), 5-(1,1-Diethoxycarbonylethyl)-1-methyl-2-(2,2-dimethylpropyl)-1*H*-imidazole (**3a**) and (4*R**,5*R**)-4,5-Di(1,1-diethoxycarbonylethyl)-4,5-dihydro-1-methyl-2-(2,2-dimethylpropyl)-1*H*-imidazole (**4a**).

General Procedure (Entry 2 in Table 1 as an example).

Sodium hydride (NaH, 60 % in oil, 200 mg, 5 mmol) was added to a suspension of **1a** (223 mg, 1 mmol) in THF (1 mL) under N_2 and ice cooling, and the mixture was stirred for 5 min at 0 °C, then diethyl methylmalonate (0.86 mL, 5 mmol) was added to the mixture and stirring was continued for 4 h at ambient temperature. Water (1 mL) was added to the reaction mixture and the products were extracted with AcOEt (5 mL x 3) and the organic layer was dried over anhydrous sodium sulfate. The solvent was evaporated to give an oily residue, which was separated by column chromatography ($CHCl_3$/MeOH = 30/1) to give **2a** (first fraction, 16 mg, 5 %), **3a** (second fraction, 85 mg, 26 %) and **4a** (third fraction, 282 mg, 57 %).

Compound **2a** was obtained as a yellow viscous oil; ir ($CHCl_3$): 2939, 1720, 1478 cm^{-1}; ^1H nmr (400 MHz, $CDCl_3$): δ 1.00 (9H, s), 1.01 (3H, t, J = 7.1 Hz), 1.29 (3H, t, J = 7.1 Hz), 1.99 (3H, s), 3.70 (3H, s), 3.81-3.88 (2H, m), 3.95 (1H, s), 4.12-4.29 (2H, m), 6.75 (1H, d, J = 1.3 Hz), 6.94 (1H, d, J = 1.1 Hz); ^{13}C nmr (100 MHz, $CDCl_3$): δ 13.80, 13.84, 17.0, 29.6 x 3, 33.4, 36.8, 47.0, 59.0, 61.4, 61.7, 119.8, 126.4, 147.5, 170.9, 172.1; ms: *m/z* 324 (M^+, 5), 268 (12), 195 (100), 149 (25), 121 (22); Hrms Calcd. for $C_{17}H_{28}N_2O_4$: $[M]^+$ = 324.2049. Found: 324.2048.

Compound **3a** was obtained as a yellow viscous oil; ir ($CHCl_3$): 2926, 1721, 1463 cm^{-1}; ^1H nmr (300 MHz, $CDCl_3$): δ 1.01 [9H, s, $C(CH_3)_3$], 1.26 [6H, t, J = 7.2 Hz, $(OCH_2CH_3)_2$], 1.90 [3H, s, $CCH_3(CO_2Et)_2$], 2.59 [2H, s, $CH_2C(CH_3)_3$], 3.49 (3H, s, NCH_3), 4.23 [4H, q, J = 7.3 Hz, $(OCH_2CH_3)_2$], 6.92 (1H, s, Im-H); ^{13}C nmr (75 MHz, $CDCl_3$): δ 13.9 x 2 [$(OCH_2CH_3)_2$], 21.9 [$CCH_3(CO_2Et)_2$], 29.6 x 3 [$C(CH_3)_3$], 32.5 (NCH_3), 32.9 [$C(CH_3)_3$], 40.0 [$CH_2C(CH_3)_3$], 53.4 [$CCH_3(CO_2Et)_2$], 62.0 x 2 [$(OCH_2CH_3)_2$], 126.6 (C-4), 128.7 (C-5), 149.2 (C-2), 170.4 x 2 [$(COOEt)_2$]; ms: *m/z* 324 (M^+, 8), 268 (100), 251 (29), 195 (96), 167 (10), 149 (35), 121 (19), 57 (10); Hrms Calcd. for $C_{17}H_{28}N_2O_4$: $[M]^+$ = 324.2049. Found: 324.2047.

Compound **4a** was obtained as a yellow viscous oil; ir ($CHCl_3$): 2954, 1719 cm^{-1}; ^1H nmr (400 MHz, $CDCl_3$): δ 1.04 (9H, s), 1.22-1.29 (12H, m), 1.37 (3H, s), 1.39 (3H, s), 2.14 (1H, d, J = 14.3 Hz), 2.19 (1H, d, J = 14.5 Hz), 2.81 (3H, s), 4.08-4.27 (8H, m), 4.37 (1H, d, J = 3.0 Hz), 4.49 (1H, d, J = 3.0 Hz); ^{13}C nmr (100 MHz, $CDCl_3$): δ 13.8, 13.87, 13.88, 13.91, 15.4, 16.8, 29.9 x 3, 31.4, 34.4, 40.2, 57.7, 57.9, 60.9, 61.1, 61.3, 61.4, 66.7, 69.9, 166.6, 170.0, 170.3, 170.4, 170.6; ms: *m/z* 498 (M^+, 3), 325 (76), 268 (100), 251 (30), 195 (43), 153 (13), 97 (13); Hrms Calcd. for $C_{25}H_{42}N_2O_8$: $[M]^+$ = 498.2941. Found: 498.2939.

2-[1-(1,1-Diethoxycarbonylethyl)-2-methylpropyl]-1-methyl-1*H*-imidazole (**2b**), 5-(1,1-Diethoxycarbonylethyl)-1-methyl-2-(2-methylpropyl)-1*H*-imidazole (**3b**) and (4*R**,5*R**)-4,5-Di(1,1-diethoxycarbonylethyl)-4,5-dihydro-1-methyl-2-(2-methylpropyl)-1*H*-imidazole (**4b**).

These compounds were prepared in a similar manner as that used for preparation of **2a**, **3a** and **4a** except for use of **1b** instead of **1a**. Title compounds were separated by column chromatography ($CHCl_3$/MeOH = 20/1).

Compound **2b** was obtained in 9 % yield (28 mg) as a yellow viscous oil; ir ($CHCl_3$): 2940, 1720 cm^{-1}; ^1H nmr (400 MHz, $CDCl_3$): δ 0.65 (3H, d, J = 6.6 Hz), 0.94 (3H, d, J = 6.6 Hz), 1.03 (3H, t, J = 7.1 Hz), 1.29 (3H, t, J = 7.1 Hz), 1.80 (3H, s), 2.19-2.32 (1H, m), 3.66 (3H, s), 3.67 (1H, d, J = 8.3 Hz), 3.88-3.93 (2H, m), 4.17-4.30 (2H, m), 6.72 (1H, d, J = 1.3 Hz), 6.94 (1H, d, J = 1.1 Hz); ^{13}C nmr (100 MHz, $CDCl_3$): δ 13.8, 13.9, 15.5, 21.5, 21.7, 31.6, 32.9, 45.3, 57.7, 61.4, 61.6, 119.5, 127.1, 148.4, 171.0, 171.5; ms: *m/z* 310 (M^+, 11), 268 (12), 237 (9), 195 (55), 137 (100), 123 (10), 96 (46); Hrms Calcd. for $C_{16}H_{26}N_2O_4$: $[M]^+$ = 310.1892. Found: 310.1897.

Compound **3b** was obtained in 10 % yield (30 mg) as a yellow viscous oil; ir ($CHCl_3$): 2936, 1722, 1460 cm^{-1}; ^1H nmr (400 MHz, $CDCl_3$): δ 0.97 (6H, d, J = 6.8 Hz), 1.27 (6H, t, J = 7.0 Hz), 1.90 (3H, s), 2.04-2.20 (1H, m), 2.55 (2H, d, J = 7.3 Hz), 3.48 (3H, s), 4.23 (4H, q, J = 7.0 Hz), 6.90 (1H, s); ^{13}C nmr (100 MHz, $CDCl_3$,): δ 13.9 x 2, 21.8, 22.5 x 2, 28.0, 31.9, 36.3, 53.3, 62.0 x 2, 126.6, 128.6, 150.4, 170.4 x 2; ms: *m/z* 310 (M^+, 27), 268 (100), 237 (87), 195 (20), 163 (9); Hrms Calcd. for $C_{16}H_{26}N_2O_4$: $[M]^+$ = 310.1892. Found: 310.1897.

Compound **4b** was obtained in 48 % yield (231 mg) as a yellow viscous oil; ir ($CHCl_3$): 2936, 1719 cm^{-1}; ^1H nmr (400 MHz, $CDCl_3$): δ 0.97 (3H, d, J = 6.4 Hz), 0.98 (3H, d, J = 6.6 Hz), 1.20-1.30 (12H, m), 1.35 (3H, s), 1.37 (3H, s), 1.93-2.03 (1H, m), 2.07 (2H, d, J = 6.6 Hz), 2.81 (3H, s), 4.08-4.28 (8H, m), 4.35 (1H, d, J = 2.9 Hz), 4.46 (1H, d, J = 2.9 Hz); ^{13}C nmr (100 MHz, $CDCl_3$): δ 13.8 x 2, 13.9 x 2, 15.2, 16.7, 22.7, 23.1, 26.3, 33.7, 36.7, 57.8, 57.9, 61.0, 61.2, 61.39, 61.42, 66.7, 69.7, 167.8, 170.0, 170.3, 170.4, 170.6; ms: *m/z* 484 (M^+, 3), 311(100), 268 (41), 237 (53), 129 (12), 74 (10); Hrms Calcd. for $C_{24}H_{40}N_2O_8$: $[M]^+$ = 484.2784. Found: 484.2782.

2-[1-(1,1-Diethoxycarbonylethyl)propyl]-1-methyl-1*H*-imidazole (**2c**), 5-(1,1-Diethoxycarbonylethyl)-1-methyl-2-propyl-1*H*-imidazole (**3c**) and (4*R**,5*R**)-4,5-Di(1,1-diethoxycarbonylethyl)-4,5-dihydro-1-methyl-2-propyl-1*H*-imidazole (**4c**).

These compounds were prepared in a similar manner as that used for preparation of **2a**, **3a** and **4a** except for use of **1c** instead of **1a**. Title compounds were separated by column chromatography (AcOEt).

Compound **2c** was obtained in 35% yield (104 mg) as a yellow viscous oil; ir ($CHCl_3$): 2940, 1721, 1456 cm^{-1}; ^1H nmr (400 MHz, $CDCl_3$): δ 0.69 (3H, t, J = 7.3 Hz), 1.08 (3H, t, J = 7.0 Hz), 1.28 (3H, t, J = 7.1 Hz), 1.63-1.71 (1H, m), 1.72 (3H, s), 1.88-2.00 (1H, m), 3.59 (1H, dd, J = 11.5, 2.9 Hz), 3.67 (3H, s), 3.94-4.02 (2H, m), 4.24 (2H, q, J = 7.1 Hz), 6.74 (1H, d, J = 1.1 Hz), 6.98 (1H, d, J = 1.1 Hz); ^{13}C nmr (100 MHz, $CDCl_3$,): δ 12.3, 13.8, 14.0, 15.8, 25.0, 32.8, 41.2, 57.9, 61.2, 61.5, 119.9, 127.3, 147.4, 171.3, 171.5; ms: *m/z* 296 (M^+, 8), 251 (9), 223 (17), 195 (8), 123 (100), 96 (11); Hrms Calcd. for $C_{15}H_{24}N_2O_4$: $[M]^+$ = 296.1736. Found: 296.1739.

Compound **3c** was obtained in 25 % yield (74 mg) as a yellow viscous oil; ir ($CHCl_3$): 2940, 1722, 1459 cm^{-1}; ^1H nmr (400 MHz, $CDCl_3$): δ 1.01 (3H, t, J = 7.3 Hz), 1.27 (6H, t, J = 7.1 Hz), 1.72-1.84 (2H, m), 1.89 (3H, s), 2.63 (2H, t, J = 7.7 Hz), 3.48 (3H, s), 4.23 (4H, q, J = 7.1 Hz), 6.88 (1H, s); ^{13}C nmr (100 MHz, $CDCl_3$): δ 13.9 x 3, 20.7, 21.7, 29.4, 31.7, 53.2, 62.0 x 2, 126.5, 128.7, 150.8, 170.3 x 2; ms: *m/z* 296 (M^+, 9), 268 (25), 223 (100), 195 (22), 149 (38); Hrms Calcd. for $C_{15}H_{24}N_2O_4$: $[M]^+$ = 296.1736. Found: 296.1733.

Compound **4c** was obtained in 30 % yield (139 mg) as a yellow viscous oil; ir ($CHCl_3$): 2945, 1719, 1604, 1444 cm^{-1}; ^1H nmr (400 MHz, $CDCl_3$): δ 0.96 (3H, t, J = 7.4 Hz), 1.22-1.29 (12H, m), 1.33 (3H, s), 1.35 (3H, s), 1.53-1.66 (2H, m), 2.10-2.22 (2H, m), 2.81 (3H s), 4.08-4.30 (8H, m), 4.32 (1H, d, J = 2.9 Hz), 4.47 (1H, d, J = 2.9 Hz); ^{13}C nmr (100 MHz, $CDCl_3$): δ 13.8, 13.90, 13.92, 13.94, 14.2, 15.2, 16.4, 20.1, 30.0, 33.5, 57.7, 58.0, 61.0, 61.2, 61.39, 61.42, 66.6, 69.4, 168.4, 170.0, 170.4 x 2, 170.6; ms: *m/z* 470 (M^+, 1), 297 (100), 268 (10), 223 (61), 149 (10), 74 (9); Hrms Calcd. for $C_{23}H_{38}N_2O_8$: $[M]^+$ = 470.2628. Found: 470.2629.

2-[1-(1,1-Diethoxycarbonylmethyl)-2,2-dimethylpropyl]-1-methyl-1*H*imidazole (**2d**), 5-(1,1-Diethoxycarbonylmethyl)-1-methyl-2-(2,2-dimethylpropyl)-1*H*-imidazole (**3d**) and (4*R**,5*R**)-4,5-Di(1,1-diethoxycarbonylmethyl)-4,5-dihydro-1-methyl-2-(2,2-dimethylpropyl)-1*H*-imidazole (**4d**).

These compounds were prepared in a similar manner as that used for preparation of **2a**, **3a** and **4a** except for use of diethyl malonate instead of diethyl methylmalonate. Title compounds were separated by column chromatography (AcOEt/*n*-hexane = 1/1).

Compound **2d** was obtained in 16 % yield (51 mg) as a yellow viscous oil; ir ($CHCl_3$): 2940, 1741, 1720, 1479 cm^{-1}; ^1H nmr (270 MHz, $CDCl_3$): δ 0.96 (9H, s), 1.03 (3H, t, J = 7.1 Hz), 1.30 (3H, t, J = 7.2 Hz), 3.54 (1H, d, J = 10.6 Hz), 3.70 (3H, s), 3.89 (2H, q, J = 7.1 Hz), 4.15 (1H, d, J = 10.6 Hz), 4.16-4.31 (2H, m), 6.72 (1H, d, J = 1.3 Hz), 6.89 (1H, d, J = 1.3 Hz); ^{13}C nmr (75 MHz, $CDCl_3$): δ 13.8, 13.9, 27.9 x 3, 33.1, 35.4, 45.0, 54.2, 61.3, 61.7, 119.8, 126.7, 148.2, 168.3, 169.5; ms: *m/z* 310 (M^+, 3), 254 (19), 181 (100), 135 (12), 96 (14); Hrms Calcd. for $C_{16}H_{26}N_2O_4$: $[M]^+$ = 310.1892. Found: 310.1903.

Compound **3d** was obtained in 61 % yield (188 mg) as a yellow viscous oil; ir ($CHCl_3$): 2934, 1730, 1464 cm^{-1}; ^1H nmr (300 MHz, $CDCl_3$,): δ 1.00 (9H, s), 1.28 (6H, t, J = 7.1 Hz), 2.59 (2H, s), 3.51 (3H, s), 4.15-4.35 (4H, m), 4.69 (1H, d, J = 0.3 Hz), 7.00 (1H, d, J = 0.5 Hz); ^{13}C nmr (75 MHz, $CDCl_3$): δ 13.9 x 2, 29.5 x 3, 31.5, 32.8, 40.0, 49.4, 62.0 x 2, 122.5, 127.8, 148.3, 166.6 x 2; ms: *m/z* 310 (M^+, 12), 254 (100), 182 (26), 110 (29); Hrms Calcd. for $C_{16}H_{26}N_2O_4$: $[M]^+$ = 310.1892. Found: 310.1903.

Compound **4d** was obtained in 7 % yield (32 mg) as a yellow viscous oil; ir ($CHCl_3$): 2941, 1722, 1387 cm^{-1}; ^1H nmr (400 MHz, $CDCl_3$): δ 1.00 (9H, s), 1.24-1.29 (12H, m), 2.09 (1H, d, J = 13.9 Hz), 2.13 (1H, d, J = 13.9 Hz), 2.88 (3H, s), 3.67 (1H, d, J = 6.4 Hz), 3.70 (1H, d, J = 4.2 Hz), 4.12-4.25 (8H, m), 4.28-4.30 (1H, br s), 4.46 (1H, dd, J = 6.4, 5.1 Hz); ^{13}C nmr (100 MHz, $CDCl_3$): δ 13.9 x 3, 14.0, 29.8 x 3, 31.5, 34.0, 39.8, 56.4, 56.8, 61.2, 61.4, 61.5, 61.6, 64.4, 68.0, 166.0, 167.2, 167.55, 167.64, 167.8; ms: *m/z* 470 (M^+, 17), 414 (74), 342 (84), 311 (100), 270 (42), 254 (99), 133 (37), 115 (40); Hrms Calcd. for $C_{23}H_{38}N_2O_8$: $[M]^+$ = 470.2628. Found: 470.2632.

2-[1-(1,1-Diethoxycarbonylpropyl)-2,2-dimethylpropyl]-1-methyl-1*H*-imidazole (**2e**), 5-(1,1-Diethoxycarbonylpropyl)-1-methyl-2-(2,2-dimethylpropyl)-1*H*-imidazole (**3e**) and (4*R**,5*R**)-4,5-Di(1,1-diethoxycarbonylpropyl)-4,5-dihydro-1-methyl-2-(2,2-dimethylpropyl)-1*H*-imidazole (**4e**).

These compounds were prepared in a similar manner as that used for preparation of **2a**, **3a** and **4a** except for use of diethyl ethylmalonate instead of diethyl methylmalonate. Title compounds were separated by column chromatography ($CHCl_3$/MeOH = 20/1).

Compound **2e** was obtained in 5 % yield (18 mg) as a yellow viscous oil; ir ($CHCl_3$): 2939, 1716, 1479 cm^{-1}; ^1H nmr (400 MHz, $CDCl_3$): δ 0.83 (3H, t, J = 7.3 Hz), 1.03 (9H, s), 1.21 (3H, t, J = 7.1 Hz), 1.33 (3H, t, J = 7.1 Hz), 1.81-1.95 (2H, m), 3.63 (3H, s), 3.72 (1H, s), 3.97-4.38 (4H, m), 6.76 (1H, d, J = 1.3 Hz), 7.02 (1H, d, J = 1.3 Hz); ^{13}C nmr (100 MHz, $CDCl_3$): δ 10.4, 13.8, 13.9, 27.8, 29.6 x 3, 33.2, 37.2, 49.9, 60.9, 61.1, 61.7, 119.4, 126.9, 146.8, 170.5, 171.8; ms: *m/z* 338 (M^+, 1), 209 (100), 163 (49), 151 (19), 135 (17); Hrms Calcd. for $C_{18}H_{30}N_2O_4$: $[M]^+$ = 338.2205. Found: 338.2209.

Compound **3e** was obtained in 32 % yield (109 mg) as a yellow viscous oil; ir ($CHCl_3$): 2935, 1720, 1462 cm^{-1}; ^1H nmr (400 MHz, $CDCl_3$): δ 1.00 (9H, s), 1.01 (3H, t, J = 7.4 Hz), 1.26 (6H, t, J = 7.1 Hz), 2.39 (2H, q, J = 7.4 Hz), 2.59 (2H, s), 3.48 (3H, s), 4.23 (4H, q, J = 7.2 Hz), 6.96 (1H, s); ^{13}C nmr (100 MHz, $CDCl_3$): δ 9.6, 13.9 x 2, 28.0, 29.6 x 3, 32.5, 32.8, 39.9, 57.7, 61.7 x 2, 127.3, 127.5, 148.9, 169.4 x 2; ms: *m/z* 338 (M^+, 9), 282 (100), 265 (35), 209 (64), 163 (22), 135 (12), 111 (16); Hrms Calcd. for $C_{18}H_{30}N_2O_4$: $[M]^+$ = 338.2205. Found: 338.2214.

Compound **4e** was obtained in 28 % yield (147 mg) as a yellow viscous oil; ir ($CHCl_3$): 2937, 1717 cm^{-1}; ^1H nmr (400 MHz, $CDCl_3$): δ 0.90 (3H, t, J = 7.3 Hz), 0.97 (3H, t, J = 7.3 Hz), 1.03 (9H s), 1.25-1.31 (12H, m), 1.70-1.80 (1H, m), 1.90-1.96 (1H, m), 2.08-2.18 (4H, m), 2.79 (3H, s), 4.05-4.27 (8H, m), 4.55 (1H, br s), 4.59 (1H, d, J = 2.4 Hz); ^{13}C nmr (100 MHz, $CDCl_3$): δ 9.5, 9.6, 13.9, 13.96, 13.98, 14.04, 25.1, 25.5, 29.8 x 3, 31.3, 33.4, 40.3, 60.8 x 2, 61.15, 61.19, 61.23, 62.2, 68.0, 68.6, 166.1, 169.3, 170.0, 170.1, 170.3; ms: *m/z* 526 (M^+, 1), 339 (100), 282 (74), 265 (38), 209 (13), 153 (19), 143 (11), 97(11); Hrms Calcd. for $C_{27}H_{46}N_2O_8$: $[M]^+$ = 526.3254. Found: 526.3260.

2-[1-(1,1-Diethoxycarbonyl-3-butenyl)-2,2-dimethylpropyl]-1-methyl-1*H*-imidazole (**2f**) and 5-(1,1-diethoxycarbonyl-3-butenyl)-1-methyl-2-(2,2-dimethylpropyl)-1*H*-imidazole (**3f**).

These compounds were prepared in a similar manner as that used for the preparation of **2a**, **3a** and **4a** except for the use of diethyl allylmalonate instead of diethyl methylmalonate. Title compounds were separated by column chromatography (AcOEt/*n*-hexane = 1/1).

Compound **2f** was obtained in 6 % yield (20 mg) as a yellow viscous oil; ir ($CHCl_3$): 2943, 1722 cm^{-1}; ^1H nmr (270 MHz, $CDCl_3$): δ 1.04 (9H, s), 1.17 (3H, t, J = 7.1 Hz), 1.33 (3H, t, J = 7.1 Hz), 2.64 (2H, d, J = 7.1 Hz), 3.63 (3H, s), 3.71 (1H, s), 3.88-4.39 (4H, m), 4.89-4.95 (2H, m), 5.70-5.86 (1H, m), 6.75 (1H, d, J = 1.1 Hz), 7.01 (1H, d, J = 1.1 Hz); ^{13}C nmr (68 MHz, $CDCl_3$): δ 13.9, 14.0, 29.8 x 3, 33.4, 37.4, 39.3, 49.4, 61.10, 61.14, 61.5, 117.2, 119.4, 126.9, 134.7, 146.6, 170.2, 171.0; ms: *m/z* 350 (M^+, 1), 253 (18), 221 (100), 207 (33), 175 (20), 147 (17), 137 (33); Hrms Calcd. for $C_{19}H_{30}N_2O_4$: $[M]^+$ = 350.2205. Found: 350.2210.

Compound **3f** was obtained in 89 % yield (310 mg) as a yellow viscous oil; ir ($CHCl_3$): 2936, 1724, 1467 cm^{-1}; ^1H nmr (400 MHz, $CDCl_3$): δ 1.00 (9H, s), 1.25 (6H, t, J = 7.1 Hz), 2.59 (2H, s), 3.10 (2H, d, J = 7.3 Hz), 3.49 (3H, s), 4.21 (4H, q, J = 7.1 Hz), 5.07-5.16 (2H, m), 5.87-5.97 (1H, m), 6.99 (1H, s); ^{13}C nmr (100 MHz, $CDCl_3$): δ 14.0 x 2, 29.6 x 3, 32.6, 32.9, 39.4, 40.0, 57.5, 61.9 x 2, 118.9, 127.4 x 2, 133.0, 149.1, 169.1 x 2; ms: *m/z* 350 (M^+, 22), 309 (84), 294 (100), 277 (67), 253 (67), 221 (27), 207 (77), 122 (23), 57 (27); Hrms Calcd. for $C_{19}H_{30}N_2O_4$: $[M]^+$ = 350.2205. Found: 350.2210.

2-[1-(1,1-Diethoxycarbonyl-1-phenylmethyl)-2,2-dimethylpropyl]-1-methyl-1*H*-imidazole (**2g**), 5-(1,1-Diethoxycarbonyl-1-phenylmethyl)-1-methyl-2-(2,2-dimethylpropyl)-1*H*-imidazole (**3g**) and 2-{1-[4-(1,1-Diethoxycarbonylmethyl)phenyl]-2,2-dimethylpropyl}-1-methyl-1*H*-imidazole (**5**).

These compounds were prepared in a similar manner as that used for preparation of **2a**, **3a** and **4a** except for the use of diethyl phenylmalonate instead of diethyl methylmalonate. Title compounds were separated by column chromatography (AcOEt/*n*-hexane = 1/1).

Compound **2g** was obtained in 3 % yield (10 mg) as colorless needles (*n*-hexane), mp 113-115 °C; ir ($CHCl_3$): 2942, 1730, 1479 cm^{-1}; ^1H nmr (400 MHz, $CDCl_3$): δ 0.72 (9H, s), 1.04 (3H, t, J = 7.1 Hz), 1.22 (3H, t, J = 7.1 Hz), 3.59 (3H, s), 3.74-3.82 (1H, m), 3.92-4.00 (1H, m), 4.20 (1H, s), 4.21-4.35 (2H, m), 6.70 (1H, d, J = 1.1 Hz), 6.98 (1H, d, J = 1.1 Hz), 7.25-7.34 (3H, m), 7.88 (2H, d, J = 7.0 Hz); ^{13}C nmr (100 MHz, $CDCl_3$): δ 13.7 x 2, 29.2 x 3, 33.3, 37.2, 48.1, 61.4, 61.6, 67.1, 119.6, 126.6, 126.7 x 2, 127.3 x 2, 131.9, 135.1, 147.7, 169.2, 171.7; ms: *m/z* 386 (M^+, 16), 329 (100), 257 (28), 151 (71); Hrms Calcd. for $C_{22}H_{30}N_2O_4$: $[M]^+$ = 386.2205. Found: 386.2204.

Anal. Calcd. for $C_{22}H_{30}N_2O_4$: C, 68.37; H, 7.82; N, 7.25. Found: C, 68.12; H, 7.82; N, 7.38.

Compound **3g** was obtained in 11 % yield (42 mg) as a yellow viscous oil; ir ($CHCl_3$): 2937, 1724, 1464 cm^{-1}; ^1H nmr (400 MHz, $CDCl_3$): δ 0.99 (9H, s), 1.28 (6H, t, J = 7.1 Hz), 2.56 (2H, s), 3.01 (3H, s), 4.31 (4H, q, J = 7.1 Hz), 7.11 (1H, s), 7.26-7.36 (5H, m); ^{13}C nmr (100 MHz, $CDCl_3$): δ 13.9 x 2, 29.6 x 3, 32.5, 32.9, 39.9, 62.4 x 2, 63.3, 127.4, 128.1, 128.3 x 2, 128.6 x 2, 128.9, 136.1, 149.0, 168.4 x 2; ms: *m/z* 386 (M^+, 14), 330 (100), 313 (50), 257 (51), 211 (30), 183 (12), 115 (13), 57 (16); Hrms Calcd. for $C_{22}H_{30}N_2O_4$: $[M]^+$ = 386.2205. Found: 386.2199.

Compound **5** was obtained in 44 % yield (171 mg) as colorless plates (*n*-hexane), mp 118-120 °C; ir ($CHCl_3$): 2936, 1722 cm^{-1}; ^1H nmr (400 MHz, $CDCl_3$): δ 1.06 (9H, s), 1.24 (3H, t, J = 7.1 Hz), 1.25 (3H, t, J = 7.1 Hz), 3.46 (3H, s), 3.77 (1H, s), 4.13-4.26 (4H, m), 4.58 (1H, s), 6.70 (1H, d, J = 1.3 Hz), 7.00 (1H, d, J = 1.1 Hz), 7.30 (2H, d, J = 8.2 Hz), 7.46 (2H, d, J = 8.2 Hz); ^{13}C nmr (100 MHz, $CDCl_3$): δ 13.9 x 2, 28.1 x 3, 32.8, 35.6, 52.5, 57.4, 61.6 x 2, 119.7, 126.5, 128.4 x 2, 130.5 x 2, 130.8, 138.7, 148.3, 168.1 x 2; ms: *m/z* 386 (M^+, 2), 330 (100), 257 (52), 227 (9), 183 (13), 170 (9); Hrms Calcd. for $C_{22}H_{30}N_2O_4$: $[M]^+$ = 386.2205. Found: 386.2197.

Anal. Calcd. for $C_{22}H_{30}N_2O_4$: C, 68.37; H, 7.82; N, 7.25. Found: C, 68.17; H, 7.76; N, 7.33.

1-Methyl-2-(1,2,2-trimethylpropyl)-1*H*-imidazole (**7a**) and 1,5-Dimethyl-2-(2,2-dimethylpropyl)-1*H*-imidazole (**8a**).

These compounds were prepared in a similar manner as that used for preparation of **2a**, **3a** and **4a** except for use of a methylmagnesium bromide (0.9 *M* solution in THF) instead of NaH and diethyl methylmalonate. Title compounds were separated by column chromatography ($CHCl_3$/MeOH = 10/1).

Compound **7a** was obtained in 21 % yield (35 mg) as a yellow viscous oil; ir ($CHCl_3$): 2932, 1473, 1359 cm^{-1}; ^1H nmr (400 MHz, $CDCl_3$): δ 0.95 (9H, s), 1.29 (3H, d, J = 7.1 Hz), 2.69 (1H, q, J = 7.1 Hz), 3.59 (3H, s), 6.73 (1H, d, J = 1.1 Hz), 6.97 (1H, d, J = 1.1 Hz); ^{13}C nmr (100 MHz, $CDCl_3$): δ 15.2, 27.5 x 3, 33.0, 35.0, 40.0, 119.4, 126.7, 151.3; ms: *m/z* 166 (M^+, 8), 151 (8), 110 (100), 96 (14), 71 (16); Hrms Calcd. for $C_{10}H_{18}N_2$: $[M]^+$ = 166.1470. Found: 166.1465.

Compound **8a** was obtained in 37 % yield (61 mg) as a yellow viscous oil; ir ($CHCl_3$): 2927, 1464, 1435, 1400, 1361 cm^{-1}; ^1H nmr (400 MHz, $CDCl_3$): δ 1.00 (9H, s), 2.17 (3H, d, J = 0.9 Hz), 2.57 (2H, s), 3.43 (3H, s), 6.71 (1H, d, J = 1.1 Hz); ^{13}C nmr (100 MHz, $CDCl_3$): δ 10.0, 29.6 x 3, 30.6, 32.8, 40.2, 124.4, 127.0, 146.3; ms: *m/z* 166 (M^+, 16), 151 (7), 110 (100), 95 (10), 71 (7); Hrms Calcd. for $C_{10}H_{18}N_2$: $[M]^+$ = 166.1470. Found: 166.1474.

1-Methyl-2-[1-(1,1-dimethylethyl)pentyl]-1*H*-imidazole (**7b**) and 5-Butyl-1-methyl-2-(2,2-dimethylpropyl)-1*H*-imidazole (**8b**).

These compounds were prepared in a similar manner as that used for preparation of **2a**, **3a** and **4a** except for use of a *n*-butylmagnesium chloride (0.9 *M* solution in THF) instead of NaH and diethyl methylmalonate. Title compounds were separated by column chromatography ($CHCl_3$/MeOH = 20/1).

Compound **7b** was obtained in 13 % yield (26 mg) as a yellow viscous oil; ir ($CHCl_3$): 2927, 1474, 1361 cm^{-1}; ^1H nmr (400 MHz, $CDCl_3$): δ 0.82 (3H, t, J = 7.3 Hz), 0.89-0.97 (2H, m), 0.94 (9H, s), 1.20-1.30 (2H, m), 1.65-1.73 (1H, m), 1.87-1.97 (1H, m), 2.45 (1H, dd, J = 11.8, 2.8 Hz), 3.57 (3H, s), 6.74 (1H, d, J = 1.1 Hz), 7.00 (1H, d, J = 1.3 Hz); ^{13}C nmr (100 MHz, $CDCl_3$): δ 14.0, 22.7, 27.9 x 3, 29.7, 30.8, 32.8, 35.1, 46.8, 119.3, 126.8, 150.6; ms: *m/z* 208 (M^+, 18), 189 (46), 151 (100), 137 (22), 123 (17), 109 (91), 96 (34); Hrms Calcd. for $C_{13}H_{24}N_2$: $[M]^+$ = 208.1939. Found: 208.1938.

Compound **8b** was obtained in 6 % yield (13 mg) as a yellow viscous oil; ir ($CHCl_3$): 2929, 2920, 1463, 1351 cm^{-1}; ^1H nmr (400 MHz, $CDCl_3$): δ 0.95 (3H, t, J = 7.4 Hz), 1.00 (9H, s), 1.37-1.46 (2H, m), 1.56-1.64 (2H, m), 2.49 (2H, dt, J = 0.7, 7.7 Hz), 2.56 (2H, s), 3.43 (3H, s), 6.70 (1H, s); ^{13}C nmr (100 MHz, $CDCl_3$): δ 13.9, 22.4, 24.5, 29.7 x 3, 30.2, 30.6, 32.8, 40.1, 123.8, 131.7, 146.3; ms: *m/z* 208 (M^+, 11), 193 (14), 151 (100), 137 (19), 123 (12), 110 (32), 58 (14); Hrms Calcd. for $C_{13}H_{24}N_2$: $[M]^+$ = 208.1939. Found: 208.1934.

2-(1-Ethyl-2,2-dimethylpropyl)-1-methyl-1*H*-imidazole (**7c**).

This was prepared in a similar manner as that used for the preparation of **2a**, **3a** and **4a** except for use of a diethyl zinc (1.0 *M* solution in *n*-hexane) instead of NaH and diethyl methylmalonate. The title compound was purified by column chromatography (Et_2O) and obtained as a pale yellow viscous oil, 49 mg (27 %); ir ($CHCl_3$): 2933, 1475, 1361 cm^{-1}; ^1H nmr (400 MHz, $CDCl_3$): δ 0.65 (3H, t, J = 7.2 Hz), 0.94 (9H, s), 1.73-1.96 (2H, m), 2.39 (1H, dd, J = 11.7, 3.1 Hz), 3.58 (3H, s), 6.74 (1H, d, J = 1.1 Hz), 7.00 (1H, d, J = 1.3 Hz); ^{13}C nmr (100 MHz, $CDCl_3$): δ 13.0, 22.9, 27.9 x 3, 32.8, 35.0, 48.8, 119.3, 126.8, 150.3; ms: *m/z* 180 (M^+, 8), 165 (9), 151 (8), 123 (97), 109 (100), 96 (20), 58 (13); Hrms Calcd. for $C_{11}H_{20}N_2$: $[M]^+$ = 180.1626. Found: 180.1634.

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