SYNTHESIS OF 1,7,10-ANTHYRIDINE DERIVATIVES

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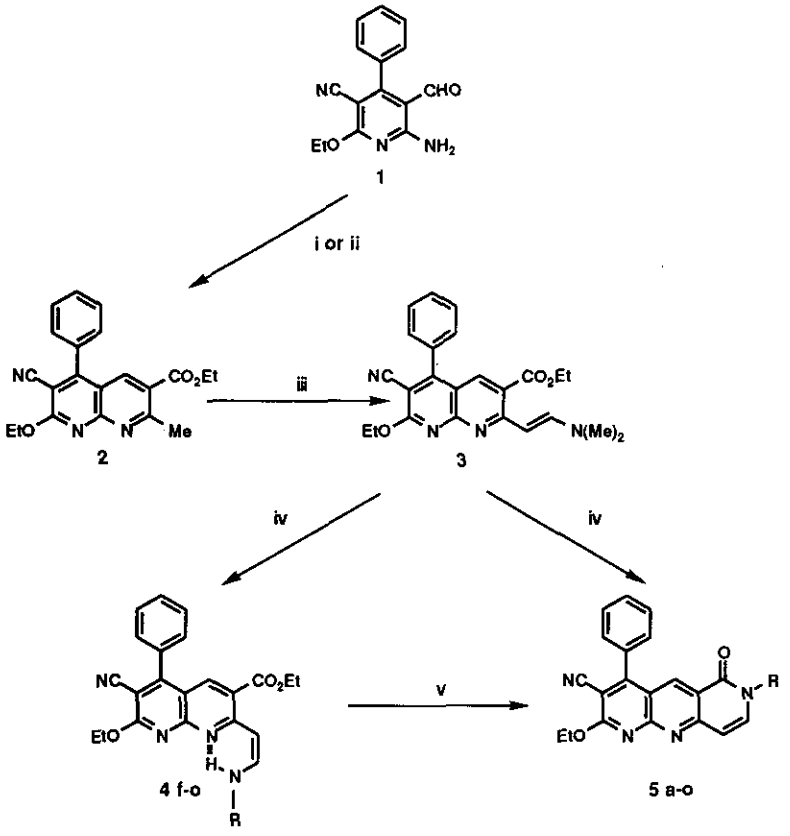
Abstract- A convenient synthesis of 7-substituted 1,7,10-anthyridin-6-(*7H*)-ones using an enamination ring closure sequence is described. This strategy makes a novel, potencially universal method for the preparation of this new tricyclic ring system.

Unlike linear carbocyclic "acene" homologous series, very little information on their analogues compounds, containing the pyridine ring as building unit is available.[1-4] Also, unlike to the linear carbocyclic series, introduction of heteroatoms into such polycondensed systems gives rise to an increasing number of isomeric ring structures.[5] There is scanty literature on the chemistry of anthyridines. Of the many possible structures for these heterocyclic systems containing three linearly annelated pyridine rings, few have actually been synthesized.[5] Such triazaanthracenes are usually synthesized from 2-substituted or 2,3-disubstituted 1,5- and 1,8-naphthyridine derivatives as starting material.[1-8] The synthesis of the anthyridine nucleus has also been accomplished by Friedländer condensation of 2,6-diaminopyridine-3,5-dicarboxaldehyde with appropiate ketones.[9] 1,9,10-Anthyridine derivatives are the most readily available on account of with affordability and promising biological properties.[10,11]

A literature scan revealed no mention to the synthesis of the 1,7,10-anthyridine system. In connection with our synthesis program on biologically active compounds, in this paper we report the first example of the formation of a series of hitherto unknown 4-substituted 1,7,10-anthyridin-6-ones.The annelated triheterocyclic compounds **(5)** were conveniently obtained as outlined in Scheme **1**.

SCHEME 1



Reagents:

i: $MeCOCH_2CO_2Et$, KOH (Ethanolic)/ EtOH, reflux;
ii: $MeCOCH_2CO_2Et$, piperidine, 140°C;
iii: DMFDMA, DMF, reflux;
iv: RNH_2, TsOH, toluene, reflux;
v: NaOEt, EtOH, room temperature.

The required 6-carboethoxy-3-cyano-2-ethoxy-7-methyl-4-phenyl-1,8-naphthyridine **(2)** was obtained by Friedländer condensation from readily available 2-aminonicotinaldehyde **(1)**[12] with ethyl acetoacetate in ethanol using piperidine as catalyst. The active methylene group in the naphthyridinecarboxylate **(2)** was reacted with dimethylformamide dimethyl acetal (DMFDMA) to give the enamino ester **(3)**, whose structure was determined from microanalyses and spectral data; according to its ^1H nmr coupling constant, J_{AB}= 12.4 Hz **(4f-o)**, it occurs in an E-configuration.

Annelation of the enamine **(3)** with primary aliphatic amines or hydrazine yielded directly the compounds **(5a-c)**. As shown in Scheme **1**, the intermediate enamine compounds **(4f-o)** could be isolated by treatment of **3** with primary aromatic or heteroaromatic amines. Only one isomer, Z-configuration (chelated via an intramolecular hydrogen-bond between the 8-nitrogen of the 1,8-naphthyridine ring and the hydrogen of the NH enamine) of these enamines was observed. The coupling constant for the vinyl proton (8.4-9.1 Hz) in the ^{1}H nmr spectra was identical with that of an analogous Z-form enamine in the pyridine[13] and pyridazine[14] homologous know compounds. Ring closure of the enamine derivatives **(4f-o)** with sodium ethoxide in ethanol at room temperature yielded the annelated 1,7,10-anthyridin-6-(7*H*)-ones **(5f-o)**.

With strong electron-withdrawing primary aromatic amines, the intermediate **(4)** was not isolated, but the reaction directly afforded the fused anthyridones **(5d-e)**. Electronic effects may influence the course of this annelation reaction: as the nucleophilicity of the amine N increased, the annelation required to build the condensed system **5** become.

Structural elucidation of all the newly synthesized compounds **4** and **5** was easier accomplished by elemental analyses and collection of spectral data (ir, ^{1}H nmr, ^{13}C nmr and ms) (Tables **1 - 4**).

In conclusion, the above results clearly show the usefulness of appropriately substituted 1,8-naphthyridines for the annelation of a pyridine moiety to the naphthyridine system and provide a means of obtaining a variety of the new to our knowledge, triheterocyclic 1,7,10-anthyridine system. Thanks to the afford ability of the starting materials, the good yield in the cyclization step and due to the simplicity of the experimental procedure, provides an efficient method for the preparation of substituted 1,7,10-anthyridines.

EXPERIMENTAL SECTION

All melting points were measured by using a Büchi 510 instrument and are uncorrected. Ir spectra (potassium bromide) were recorded on a Perkin-Elmer 383 spectrophotometer. ^{1}H and ^{13}C nmr spectra were recorded at 250 MHz on a Bruker WM 250 spectrometer. Chemical shifts are given on the scale and using tetramethylsilane as internal standard. Electron impact mass spectra (ms) were recorded at 70 eV, on a Kratos MS-50 spectrometer. Microanalyses for C, H and N were performed by the Elemental Analyses General Service of the University of Santiago. Silica gel $HF_{254+366}$ for thin layer chromatography and silica gel 60 (230-400 mesh) for medium-pressure chromatography (mplc) were purchased from Merck. All reagents used were commercial grade chemicals from freshly opened containers.

3-Cyano-2-ethoxy-6-ethoxycarbonyl-4-phenyl-7-methyl-1,8-naphthyridine (2)

Method A. A solution of 6-amino-3-cyano-2-ethoxy-5-formyl-4-phenylpyridine (**1**, 0.35 g, 1.4 mmol) and a catalytic amount of 10 % ethanolic potassium hydroxide in ethanol (25 ml), was refluxed for 16 h. After cooling, the solid was filtered off and recrystallized from ethanol to yield **2** (0.33 g, 70%).

Method B. A mixture of 6-amino-3-cyano-2-ethoxy-5-formyl-4-phenylpyridine(**1**, 1.0 g, 3.7 mmol), piperidine(0.5 ml) and ethyl acetoacetate (30 ml) was heated at 140°C for 20 h. After cooling, the precipitate was collected and washed with ethanol. Recrystallization from ethanol provided 1.01 g (75 %) of colourless crystals, mp 224-25 °C. ^{1}H Nmr ($CDCl_3$/TMS)δ: 1.33 (3H, t, J=7.1 Hz); 1.53 (3H, t, J=7.1 Hz); 3.02 (3H, s); 4.34 (2H, q, J=7.1 Hz); 4.78 (2H, q, J=7.1 Hz); 7.26-7.62 (5H, m); 8.47 (1H, s).^{13}C Nmr ($CDCl_3$/TMS)δ: 14.0; 14.2; 25.8; 61.6; 64.6; 99.5; 139.9; 166.7. Ms (70ev) m/z (%): 361 (M^+, 45); 360 (100); 333 (83); 332 (31). Ir (KBr): 2230 (CN); 1725 (CO). Anal. Calcd for $C_{21}H_{19}N_3O_3$: C, 69.79; H, 5.30; N, 11.63; O, 13.28. Found: C, 69.82; H, 5.27; N, 11.60; O, 13.31.

3-Cyano-2-ethoxy-6-ethoxycarbonyl-7-[2-(N,N,-dimethylamino)ethenyl]-4-phenyl-1,8-naphthyridine (3)

A solution of **2** (1.0 g, 2.8 mmol) and dimethylformamide dimethyl acetal (0.37 g, 3.1 mmol) in dimethylformamide (25 ml) was refluxed for 24 h. After cooling, the solid was filtered off. The mixture was evaporated and the solid residue was subjected to column chromatography (4:1 dichloromethane-hexane) to obtain 0.81 g (70%) of orange needles, mp 250-251 °C. ^{1}H Nmr ($CDCl_3$/TMS)δ: 1.25 (3H, t, J=7.1 Hz); 1.48 (3H, t, J=7.1 Hz); 3.03 (6H, br s); 4.24 (2H, q, J=7.1 Hz); 4.70 (2H, q, J=7.1 Hz); 6.26 (1H, d, J=12.4 Hz); 7.42-7.54 (5H, m); 8.15 (1H, s); 8.31 (1H, d, J=12.4 Hz). ^{13}C nmr ($CDCl_3$/TMS)δ: 14.0; 14.3; 61.0; 63.6; 93.5; 94.5; 140.0; 166.4. Ms (70ev) m/z (%): 416 (M^+, 40); 388 (100); 360 (59); 315 (33). Ir (KBr): 2220 (CN); 1715 (CO). Anal. Calcd for $C_{24}H_{24}N_4O_3$: C, 69.21; H, 5.81; N, 13.45; O, 11.53. Found: C, 69.18; H, 5.86; N, 13.42; O, 11.54.

3-Cyano-2-ethoxy-6-ethoxycarbonyl-7-(2-arylamino)ethenyl-4-phenyl-1,8-naphthyridine (4f-o); General procedure:

A solution of **3** (0.15 g, 0.36 mmol), a suitable aromatic or heterocyclic amine (0.38 mmol) and a catalytic amount of *p*-toluenesulphonic acid in toluene (10 ml) was refluxed until the reaction was completed. After cooling, the precipitate was filtered off and recrystallized from a suitable solvent or purified by medium-pressure chromatography.

For the reaction conditions, analytical, physical and spectroscopic data, see Tables **1** and **2**.

3-Cyano-2-ethoxy-6-oxo-4-phenyl-6,7-dihydroanthyridines (5a-e); General Procedure:

To a solution containing 0.15 g (0.36 mmol) of the enamine intermediate **(3)** and 0.38 mmol of hydrazine or the appropriate primary aliphatic or aromatic amine in toluene (10 ml) was added a catalytic amount of *p*-toluenesulphonic acid. The solution was refluxed until the reaction was completed. After cooling, the precipitate was collected and recrystallized from a suitable solvent or purified by medium-pressure chromatography.

3-Cyano-2-ethoxy-6-oxo-4-phenyl-6,7-dihydroanthyridines (5f-o); General Procedure:

To 0.36 mmol of an appropriate compound **(4f-o)** in an ethanol suspension (5 ml) was added a catalytic amount of sodium ethoxide. The mixture was stirred at room temperature until the reaction was completed. The precipitate obtained was filtered off and recrystallized from a siutable solvent or purified by medium-pressure cromatography.

For the reaction conditions, analytical, physical and spectroscopic data, see Tables **3** and **4**.

Table 1

3-Cyano-2-ethoxy-6-ethoxycarbonyl-7-[2-(*N*-substituted amino)vinyl]-4-phenyl-1,8-naphthyridines (**4f-o**).

No.	R	Reac. time (h)	Yield (%)	mp (°C)	Molecular formula	Analysis (%) Calcd/Found		
						C	H	N
4f		24	53 [a]	220-222	$C_{28}H_{24}N_4O_3$	72.39 71.95	5.21 5.39	12.06 12.18
4g		9	65 [a]	220-221	$C_{30}H_{28}N_4O_3$	73.15 72.97	5.73 6.01	11.37 11.12
4h		30	56 [a]	195-196	$C_{31}H_{30}N_4O_3$	73.50 73.86	5.97 5.79	11.06 11.25
4i		27	50 [a]	221-222	$C_{28}H_{23}N_5O_5$	66.00 65.79	4.55 4.72	13.74 13.39
4j		30	35 [b]	223-224	$C_{28}H_{23}N_5O_5$	66.00 65.85	4.55 4.67	13.74 13.50
4k		10	83 [a]	205-206	$C_{32}H_{26}N_4O_3$	74.69 74.37	5.09 5.25	10.89 11.70
4l		40	74 [a]	269-271	$C_{31}H_{25}N_5O_3$	72.22 71.99	4.88 4.67	13.58 13.45
4m		33	59 [a]	230-232	$C_{26}H_{22}N_6O_3$	66.94 66.69	4.75 4.98	18.01 18.25
4n		40	65 [a]	233-235	$C_{26}H_{22}N_6O_3$	66.94 66.78	4.75 5.00	18.01 18.17
4o		12	56 [a]	210-212	$C_{28}H_{22}N_4O_3Cl_2$	63.05 63.26	4.16 3.91	10.50 10.75

[a] Recrystallized from ethanol/acetone. [b] Purified by column chromatography on silica gel with 0.5 % ethanol in dichloromethane.

Table 2

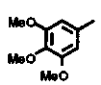
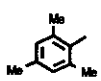
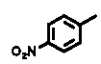
3-Cyano-2-ethoxy-6-ethoxycarbonyl-7-[2-(*N*-substituted amino)vinyl]-4-phenyl-1,8-naphthyridines (**4f-o**).

No.	Ir (KBr) ν (cm^{-1})	Ms(70eV) m/z(%)	^{1}H-Nmr ($DCCl_3$ / TMS) δ, J (Hz)	^{13}C-Nmr ($DCCl_3$/ TMS) δ
4f	2220 (CN) 1705 (CO)	464 (M^+, 76); 435 (62); 419 (6); 391 (92); 389 (18); 76 (100)	1.22 (3H, t, J=7.1); 1.50(3H, t, J=7.1); 4.22 (2H, q, J=7.1); 4.67 (2H, q, J=7.1); 6.37 (1H, d, J=8.5); 6.92-7.50 (11H, m); 8.19 (1H, s); 12.98 (1H, d, J=11.8)	14.0; 14.3; 61.3; 63.8
4g	2220 (CN) 1710 (CO)	492 (M^+, 69); 419 (5); 391 (5); 130 (100)	1.31 (3H, t, J=7.1); 1.36 (3H, t, J=7.4); 1.54 (3H, t, J=7.1); 3.09 (2H, q, J=7.4); 4.31 (2H, q, J=7.1); 4.70 (2H, q, J=7.1); 6.50 (1H, d, J=8.4); 7.01-7.26 (4H, m); 7.44-7.60 (6H, m); 8.27 (1H, s); 13.05 (1H, d, J=11.7)	13.6; 14.0; 14.3; 24.5; 61.3; 63.6; 94.8; 95.9; 112.6; 114.8; 165.8
4h	2220 (CN) 1710 (CO)	506 (M^+, 100); 477 (59); 449 (28); 433 (41); 431 (25); 405 (27); 120 (66)	1.23 (3H, t, J=7.1); 1.42 (3H, t, J=7.1); 2.22 (3H, s); 2.37 (6H, s), 4.23 (2H, q, J=7.1); 4.57 (2H, q, J=7.1); 6.27 (1H, d, J=8.6); 7.05-7.52 (7H, m); 8.18 (1H, s); 12.65 (1H, d, J=11.7)	14.1; 14.3; 19.0; 20.1; 61.3; 63.8; 92.1; 95.4; 112.3; 115.1; 166.0
4i	2220 (CN) 1715 (CO)	509 (M^+, 69); 480 (74); 452 (100); 436 (58); 434 (14); 408 (67)	1.34 (3H, t, J=7.1); 1.63 (3H, t, J=7.1); 4.35 (2H, q, J=7.1); 4.80 (2H, q, J=7.1); 6.45 (1H, d, J=8.7); 7.14-7.64 (7H, m); 8.26-8.29 (1H, m); 8.41(1H, s); 13.45 (1H, d, J=11.5)	[a]
4j	2215 (CN) 1715 (CO)	509 (M^+, 100); 418 (12); 376 (25); 302 (12)	1.33 (3H, t, J=7.1); 1.58 (3H, t, J=7.1); 4.32 (2H, q, J=7.1); 4.92 (2H, q, J=7.1); 6.82 (1H, d, J=9.1); 7.01-7.10 (1H, m); 7.37-7.64 (8H, m); 8.24-8.29 (1H, m); 8.42(1H, s); 13.73 (1H, d, J=11.5)	14.1; 14.5; 61.6; 64.8; 100.5; 113.7; 114.7; 158.3; 160.7; 164.2; 165.6
4k	2220 (CN) 1710 (CO)	514 (M^+, 44); 485 (17); 457 (26); 441 (32); 439 (33); 413 (41); 127 (100)	1.34 (3H, t, J=7.2), 1.61 (3H, t, J=7.1); 4.35 (2H, q, J=7.1); 4.88 (2H, q, J=7.1); 6.24 (1H, d, J=8.5); 7.33 (1H, d, J=7.4); 7.46-7.92 (12H, m); 8.35 (1H, s); 8.75 (1H, m); 13.69 (1H, d, J=11.7)	14.1; 14.4; 61.4; 63.8; 95.8; 96.1; 112.8; 114.8; 165.8
4l	2220 (CN) 1710 (CO)	515 (M^+, 100); 486 (90); 458 (21); 442 (6); 414 (39); 169 (15)	1.33 (3H, t, J=7.2); 1.61 (3H, t, J=7.1); 4.34 (2H, q, J=7.2); 4.77 (2H, q, J=7.1); 6.67 (1H, d, J=8.6); 7.46-7.71 (10H, m); 8.02 (1H, d, J=8.1); 8.34 (1H, d, J=3.4); 8.83 (1H, s); 13.58 (1H, d, J=11.7)	14.1; 14.3; 61.5; 64.1; 96.7; 97.0; 113.0; 114.6; 165.6
4m	2220 (CN) 1715 (CO)	466 (M^+, 26); 437 (20); 421(3); 393 (5); 120 (100)	1.32 (3H, t, J=7.1); 1.59 (3H, t, J=7.1); 4.34 (2H, q, J=7.1); 4.83 (2H, q, J=7.1); 6.65 (1H, d, J=9.1); 6.85 (1H, t, J=4.8); 7.25-7.62 (5H, m); 8.04 (1H, dd, J=9.3); 8.36 (1H, s); 8.53(2H, d, J=4.8); 12.68 (1H, d, J=11.3)	14.0; 14.3; 61.6; 64.3; 98.4; 113.9; 114.6
4n	2225 (CN) 1715 (CO)	466 (M^+, 36); 437 (28); 409 (20); 393 (12); 391 (17); 365 (17); 120 (100)	1.32 (3H, t, J=7.1); 1.60 (3H, t, J=7.1); 4.33 (2H, q, J=7.1); 4.77 (2H, q, J=7.1); 6.70 (1H, d, J=9.0); 7.26-7.97 (5H, m); 8.02-8.38 (5H, m); 13.48 (1H, d, J=11.4)	14.0; 14.2; 61.6; 64.2; 98.4; 113.4; 114.4; 165.5
4o	2220 (CN) 1725 (CO)	537 (M^+4, 10); 536 (M^+3, 12); 535 (M^+2, 23); 534 (M^+1, 69); 533 (M^+, 36); 532 (99); 505 (57); 477 (67); 475 (94); 431 (100)	1.24 (3H, t, J=7.1); 1.52 (3H, t, J=7.1); 4.24 (2H, q, J=7.1); 4.68 (2H, q, J=7.1); 6.45 (1H, d, J=8.6); 6.82-6.86 (1H, m); 7.08-7.54 (1H, m); 8.24 (1H, s); 13.12 (1H, d, J=11.7)	14.0; 14.3; 61.5; 64.0; 95.9; 96.9; 112.9; 114.6; 165.5

[a] Insoluble in most common nmr solvents.

Table 3

3-Cyano-2-ethoxy-6-oxo-6,7-dihydro-4-phenyl-7-substituted 1,7,10-anthyridines (**5a-o**).

No.	R	Reac. time (h)	Yield (%)	mp (°C)	Molecular formula	Analysis (%) Calcd/Found		
						C	H	N
5a	$CH_3(CH_2)_3$—	24	75 [a]	285-287	$C_{24}H_{22}N_4O_2$	72.34 72.01	5.56 5.89	14.06 14.38
5b		15	82 [a]	290-292	$C_{28}H_{22}N_4O_2$	75.32 75.67	4.97 4.71	12.55 12.32
5c	H_2N—	4	77 [a]	>300	$C_{20}H_{15}N_5O_2$	67.22 66.99	4.30 4.12	19.60 19.53
5d		53	83 [b]	286-288	$C_{29}H_{24}N_4O_5$	68.49 68.65	4.76 4.88	11.02 11.10
5e		4	70 [c]	281-262	$C_{26}H_{19}N_5O_2$	72.04 72.10	4.42 4.29	16.16 16.05
5f		8	43 [a]	295-296	$C_{26}H_{18}N_4O_2$	74.63 74.94	4.34 4.50	13.39 13.11
5g		24	88 [c]	>300	$C_{28}H_{22}N_4O_2$	75.32 75.69	4.97 4.63	12.53 12.68
5h		8	85 [a]	>300	$C_{29}H_{24}N_4O_2$	75.63 75.87	5.25 4.99	12.17 12.05
5i		2	41 [b]	290-2	$C_{26}H_{17}N_5O_4$	67.38 67.10	3.70 4.00	15.11 15.39
5j		2	55 [b]	>300	$C_{26}H_{17}N_5O_4$	67.38 66.89	3.70 4.07	15.11 15.29
5k		2	50 [c]	>300	$C_{30}H_{20}N_4O_2$	76.91 76.86	4.30 4.05	11.96 11.75
5l		8	47 [b]	>300	$C_{29}H_{19}N_5O_2$	74.19 73.97	4.08 4.37	14.92 14.75
5m		3	71 [b]	>300	$C_{24}H_{16}N_6O_2$	68.56 68.92	3.84 4.06	19.99 19.77
5n		8	37 [b]	>300	$C_{24}H_{16}N_6O_2$	68.56 68.83	3.84 3.68	19.99 19.85
5o		8	66 [a]	254-255	$C_{26}H_{16}N_4O_2Cl_2$	64.08 64.38	3.31 3.45	11.50 11.29

[a] Recrystallized from ethanol/acetone. [b] Purified by column on silica gel with 0.5% ethanol in dichloromethane. [c] Purified by column on silica gel with dichloromethane.

Table 4

3-Cyano-2-ethoxy-6-oxo-6,7-dihydro-4-phenyl-7-substituted 1,7,10-anthyridines (**5a-o**).

No.	Ir (KBr) ν (cm^{-1})	Ms (70eV) m/z(%)	^{1}H-Nmr ($DCCl_3$/TMS) δ, J (Hz)	^{13}C-Nmr ($DCCl_3$/TMS) δ
5a	2220 (CN) 1655 (CO)	398 (M^+, 5); 341 (6); 41(100)	0.94 (3H, t, J=7.3); 1.38 (2H, m); 1.54 (3H, t, J=7.1); 1.72 (2H, m); 3.95 (2H, t, J=7.3); 4.80 (2H, q, J=7.1); 6.88 (1H, d, J=7.7); 7.26-7.62 (6H, m); 7.71 (1H, d, J=7.9); 9.00 (1H, s)	13.5; 14.2; 19.8; 31.1; 49.1; 64.6; 99.6; 107.4; 114.0
5b	2220 (CN) 1660 (CO)	446 (M^+, 3); 417 (5); 297 (36); 91 (100)	1.56 (3H, t, J=7.0); 3.05 (2H, t, J=7.1); 4.18 (2H, t); 4.84 (2H, q, J=7.1); 6.76 (1H, d, J=7.8); 7.08-7.64 (11H, m); 9.05 (1H, s)	14.2; 35.1; 51.4; 64.7; 99.7; 107.1; 114.0
5c	3330 (NH) 3290 (NH) 2220 (CN) 1660 (CO)	357 (M^+, 25); 329 (29); 299 (40); 43 (100)	1.56 (3H, t, J=7.1); 4.82 (2H, q, J=7.0); 5.04 (2H, br s); 6.89 (1H, d, J=7.9); 7.26-7.65 (5H, m); 7.71 (1H, d, J=7.9); 9.01 (1H, s)	14.2; 64.8; 100.1; 106.7; 113.9
5d	2220 (CN) 1670 (CO)	508 (M^+, 55); 493 (25); 354 (100); 341 (8); 339 (39); 296 (15)	1.57 (3H, t, J=7.1); 3.85 (6H, s); 3.90 (3H, s); 4.84 (2H, q, J=7.1); 6.60 (2H, s); 6.99 (1H, d, J=7.8); 7.48-7.63 (6H, m); 9.06 (1H, s)	14.2; 56.2; 60.9; 64.8; 104.3; 107.6; 114.0
5e	3440 (NH) 3360 (NH) 2225 (CN) 1680 (CO)	433 (M^+, 30); 417 (32); 416 (100)	1.57 (3H, t, J=7.1); 3.75 (2H, br s); 4.84 (2H, q, J=7.1); 6.85-7.62 (11H, m); 9.04 (1H, s)	14.2; 64.8; 108.4
5f	2220 (CN) 1660 (CO)	418 (M^+, 31); 417 (27); 390 (26); 389 (24); 77 (100)	1.57 (3H, t, J=7.1); 4.83 (2H, q, J=7.1); 6.97 (1H, d, J=7.8); 7.27-7.62 (11H, m); 9.03 (1H, s)	14.2; 64.7; 99.8; 107.7; 113.9
5g	2220 (CN) 1670 (CO)	446 (M^+, 45); 429 (100); 401 (33)	1.14 (3H, t, J=7.6); 1.58 (3H, t, J=7.1); 2.44-2.54 (2H, m); 4.85 (2H, q, J=7.1); 6.99 (1H, d, J=7.7); 7.20 (1H, d, J=7.5); 7.30-7.61 (9H, m); 9.07 (1H, s)	14.1; 14.3; 24.0; 64.8; 99.9; 107.5; 114.1
5h	2220 (CN) 1665 (CO)	460 (M^+, 57); 443 (100); 415 (50)	1.57 (3H, t, J=7.1); 2.06 (6H, s); 2.33 (3H, s); 4.84 (2H, q, J=7.1); 6.97 (2H, s); 7.01 (1H, d, J=7.5); 7.26(1H, d, J=7.7); 7.49-7.61 (5H, m), 9.08 (1H, s)	14.2; 17.6; 20.9; 64.7; 99.7; 108.1; 114.1
5i	2220 (CN) 1675 (CO)	463 (M^+, 44); 435 (32); 434 (14); 43 (100)	1.58 (3H, t, J=7.1); 4.84 (2H, q, J=7.1); 7.07 (1H, d, J=7.9); 7.49-7.67 (8H, m); 8.35-8.40 (2H, m); 9.05 (1H, s)	14.2; 65.0; 109.0
5j	2220 (CN) 1660 (CO)	463 (M^+, 44); 418 (52); 389 (100)	1.57 (3H, t, J=7.1); 4.85 (2H, q, J=7.0); 7.07 (1H, d, J=7.8); 7.45-7.83 (9H, m); 8.15 (1H, dd, J=1.4, J=7.1); 8.98 (1H, s)	14.2; 64.9; 100.1; 108.9; 114.0
5k	2225 (CN) 1670 (CO)	468 (M^+, 100); 440 (36); 439 (63); 423 (26)	1.59 (3H, t, J=7.1); 4.88 (2H, q, J=7.1); 7.05 (1H, d, J=7.7); 7.26-7.62 (12H, m); 7.97 (2H, t, J=8.4); 9.10 (1H, s)	14.3; 64.8; 99.8; 107.6; 114.0
5l	2220 (CN) 1670 (CO)	469 (M^+, 97); 468 (77); 441 (39); 424 (13); 43 (100)	1.57 (3H, t, J=7.1); 4.84 (2H, q, J=7.1); 7.04 (1H, d, J=7.9); 7.51-7.82 (9H, m); 8.13-8.20 (2H, m); 9.02 (1H, s)	14.2; 64.9; 100.1; 108.7; 113.9
5m	2220 (CN) 1680 (CO)	420 (M^+, 54); 392 (44); 375 (7); 79 (100)	1.57 (3H, t, J=7.1); 4.84 (2H, q, J=7.1); 7.01 (1H, d, J=8.0); 7.37-7.63 (6H, m); 8.01 (1H, d, J=8.0); 8.89 (2H, d); 9.09 (1H, s)	14.2; 65.0; 107.9
5n	2225 (CN) 1680 (CO)	420 (M^+, 78); 392 (66); 375 (11); 363 (15); 43 (100)	1.58 (3H, t, J=7.1); 4.85 (2H, q, J=7.1); 7.10 (1H, d, J=8.0); 7.49-7.67 (5H, m); 8.19 (1H, d, J=8.1); 8.56-8.60 (2H, m); 9.07 (1H, s)	14.2; 64.9; 99.9; 109.4
5o	2220 (CN) 1670 (CO)	486 (M^+ 1, 96); 487, (M^+, 100); 460 (51)	1.57 (3H, t, J=7.1); 4.85 (2H, q, J=7.1); 6.97 (1H, d, J=7.8); 7.24-7.28 (1H, m); 7.44-7.63 (9H, m); 8.98 (1H, s)	14.2; 64.9; 100.0; 108.5, 113.9

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