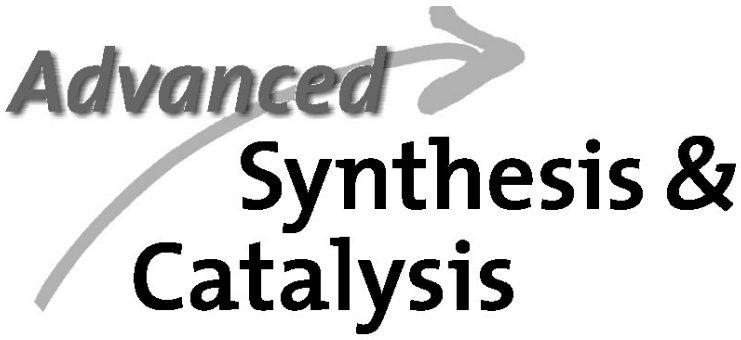

Supporting Information

Synthesis of N-Heteroaryl-Trifluoromethyl-Hydroxyl Alkanoic Acid Esters by Highly Efficient Solid Acid Catalyzed Hydroxyalkylation of Indoles and Pyrroles with Activated Trifluoromethyl Ketones

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Supporting Information

Product Identification and Analysis The products were characterized by NMR (^{1}H, ^{13}C, ^{19}F) spectroscopy using superconducting Varian Innova 400 MHz spectrometer. The spectra were recorded in $CDCl_3$ using TMS as internal standard for ^{1}H and $CFCl_3$ for ^{19}F spectra. The mass spectrometric analyses of products have been carried by Shimadzu QP5050 gas chromatograph-mass spectrometer.

2-Hydroxyl-2-(indol-3-yl)-3,3,3-trifluoropropionic acid ethyl ester. ***(Table-2, Entry-1),*** colorless crystals. (m.p. 70.5-71.8 ^{o}C). ^{1}H NMR (399.81 MHz, $CDCl_3$), d (ppm) 8.25 (bs, 1H, NH), 7.89 (d, *J*=8.3 Hz, 1H, Ar), 7.45 (d, *J*=2.3 Hz, 1H, Ar), 7.35 (dd, *J*=7.99, 1.19 Hz,1H, Ar), 7.21 (dd, *J*= 7.19, 1.19 Hz, 1H, Ar), d 7.14 (ddd, *J*=7.19, 1.19 Hz, 1H, Ar), 4.44 (dq, *J*=7.2, 3.6 Hz, 1H, CH_2), 4.39 (s, 1H, OH), 4.34 (dq, *J*=7.2, 3.6 Hz, 1H, CH_2), 1.35 (td, *J*=7.2 Hz, 3H, CH_3).^{13}C NMR (100.53 MHz, $CDCl_3$), d (ppm) 169.6, 136.5, 125.3, 125.1, 124.5, 122.9, 122.3, 121.4, 120.7, 111.5, 108.9, 64.4, 14.1, ^{19}F NMR (376.19 MHz, $CDCl_3$, $CFCl_3$-Ref), d (ppm) -77.15 (s, 3F). MS-$C_{13}H_{12}F_3NO_3$ (287), m/z (%): 287 (M^+, 33), 214 (100), 144 (65), 117 (70), 89 (30).

2-Hydroxyl-2-(5-iodo-indol-3-yl)-3,3,3-trifluoropropionic acid ethyl ester. ***(Table-2, Entry-2),*** Dark brown crystals. (m.p. 74.3-76 ^{o}C), ^{1}H NMR (399.81 MHz, $CDCl_3$), d (ppm) 8.35 (bs, 1H, NH), 8.27 (s, 1H, Ar), 7.45 (dd, *J*=8.8, 2.0 Hz, 1H, Ar), 7.40 (d, *J*=2.4 Hz, 1H, Ar), 7.11 (dd, *J*=8.8, 0.4 Hz, 1H, Ar), 4.44 (dq, *J*=7.2, 3.6 Hz, 1H, CH_2), 4.38 (s, 1H, OH), 4.35 (dq, *J*=7.2, 3.6 Hz, 1H, CH_2), 1.36 (td, *J*=7.2 Hz, 3H, CH_3). ^{13}C NMR (100.54 MHz, $CDCl_3$), d (ppm) 169.3,

135.6, 131.3, 130.4, 127.4, 125.5, 124.9, 122.1, 113.4, 108.3, 84.5, 64.7, 14.1, ^{19}F NMR (376.15 MHz, $CDCl_3$, $CFCl_3$-Ref), d (ppm) -77.46 (s, 3F), MS-$C_{13}H_{11}F_3INO_3$ (413), m/z (%): 413 (M^+, 33), 340 (60), 270 (20), 144 (100).

2-Hydroxyl-2-(2-methyl-indol-3-yl)-3,3,3-trifluoropropionic acid ethyl ester. ***(Table-2, Entry-3),*** Red crystals. (m.p. 67-68.5 ^oC). ^{1}H NMR (399.81 MHz, $CDCl_3$), d (ppm) 7.99 (bs, 1H, NH), 7.79 (d, *J*=7.9 Hz, 1H, Ar), 7.24 (dq, *J*=6.7, 0.7 Hz, 1H, Ar), 7.12 (ddd, *J*=7.1, 1.1, Hz, 1H, Ar), 7.08 (ddd, *J*=6.7, 1.1 Hz, 1H.Ar), 4.43 (dq, *J*=7.2, 3.6 Hz, 1H, CH_2), 4.34 (dq, *J*=7.2, 3.6 Hz, 1H, CH_2), 3.95 (s, 1H, OH), 2.51 (s, 3H, CH_3), 1.33 (t, *J*=7.19 Hz, 3H, CH_3). ^{13}C NMR (100.54 MHz, $CDCl_3$), d (ppm) 169.5, 135.4, 134.8, 127, 125.5, 122.7, 121.8, 120.7, 120.4, 110.4, 104.1, 63.77, 14.4, 14.0, ^{19}F NMR (376.15 MHz, $CDCl_3$, $CFCl_3$-Ref), d (ppm) -77.91 (s, 3F). MS-$C_{14}H_{14}F_3NO_3$ (301), m/z (%): 301 (M^+, 30), 228 (100), 158 (66), 131 (90).

2-Hydroxyl-2-(5-chloro-indol-3-yl)-3,3,3-trifluoropropionic acid ethyl ester. ***(Table-2, Entry-4),*** Red crystals. (m.p. 51-52.3 ^oC). ^{1}H NMR (399.81 MHz, $CDCl_3$), d (ppm) 8.30 (bs, 1H, NH), 7.91 (t, *J*=0.8 Hz, 1H, Ar), 7.50 (d, *J*=2.8 Hz, 1H, Ar), 7.28 (dd, *J*=8.8, 0.8 Hz, 1H, Ar), 7.17 (dd, *J*=6.8, 2.0 Hz, 1H, Ar), 4.45 (dq, *J*=7.2, 3.6 Hz, 1H, CH_2), 4.41 (s, 1H, OH), 4.36 (dq, *J*=7.2, 3.6 Hz, 1H, CH_2), 1.36 (td, *J*=7.2 Hz, 3H, CH_3). ^{13}C NMR (100.54 MHz, $CDCl_3$), d (ppm) 169.3, 134.9, 126.5, 126.3, 125.9, 125, 123.2, 122.1, 121.1, 112.5, 108.3, 64.6, 14.0, ^{19}F NMR (376.15 MHz, $CDCl_3$, $CFCl_3$-Ref), d (ppm) -77.53 (s, 3F). MS-$C_{13}H_{11}F_3ClNO_3$ (321), m/z (%): 321 (M^+, 20), 248 (100), 178 (60), 151 (85).

2-Hydroxyl-2-(5-bromo-indol-3-yl)-3,3,3-trifluoropropionic acid ethyl ester. ***(Table-2, Entry-5),*** Reddish-brown crystals. (m.p. 51-52.5 ^oC). ^{1}H NMR (399.81 MHz, $CDCl_3$), d (ppm) 8.32 (bs, 1H, NH), 8.07 (t, *J*=0.7 Hz, 1H, Ar), 7.47 (d, *J*=2.7 Hz, 1H, Ar), 7.29 (dd, *J*=8.8, 2.0 Hz, 1H, Ar), 7.22 (dd, *J*=8.8, 0.3 Hz, 1H, Ar), 4.45 (dq, *J*=7.2, 3.6 Hz, 1H, CH_2), 4.39 (s, 1H, OH), 4.36 (dq, *J*=7.2, 3.9 Hz, 1H, CH_2), 1.36 (td, *J*=7.2 Hz, 3H, CH_3). ^{13}C NMR (100.54 MHz, $CDCl_3$), d (ppm) 169.3, 135.2, 127.0, 125.9, 125.8, 125, 124.26, 122.1, 114.2, 112.9, 108.7, 64.7, 14.1, ^{19}F NMR (376.15 MHz, $CDCl_3$, $CFCl_3$-Ref), d (ppm) -77.5 (s, 3F). MS-$C_{13}H_{11}F_3BrNO_3$ (367), m/z (%): 367 (M^+, 10), 295 (45), 225 (20), 144 (100).

2-Hydroxyl-2-(5-methoxy-indol-3-yl)-3,3,3-trifluoropropionic acid ethyl ester. ***(Table-2, Entry-6),*** Colorless crystals. (m.p. 74.5-75.8 ^oC) ^{1}H NMR (399.81 MHz, $CDCl_3$), d (ppm) 8.25 (bs, 1H, NH), 7.40 (d, *J*=2.8 Hz, 1H, Ar), 7.35 (d, *J*=2.4 Hz, 1H, Ar), 7.22 (d, *J*=8.8 Hz, 1H, Ar), 6.87 (dd, *J*=8.8, 2.4 Hz, 1H, Ar), 4.45 (dq, *J*=7.2, 3.6 Hz, 1H, CH_2), 4.40 (s, 1H, OH), 4.34 (dq,

J=7.2, 3.6 Hz, 1H, CH_2), 3.83 (s, 3H, CH_3), 1.34 (td, *J*=7.2 Hz, 3H, CH_3). ^{13}C NMR (100.53 MHz, $CDCl_3$), d (ppm) 169.6, 154.7, 131.6, 125.9, 125.2, 125, 122.3, 113.4, 112.2, 108.5, 103, 64.4, 56.0, 14.2, ^{19}F NMR (376.15 MHz, $CDCl_3$, $CFCl_3$-Ref), d (ppm) -77.15 (s, 3F), MS-$C_{14}H_{14}F_3NO_4$(317), m/z (%): 317 (M^+, 25), 244 (95), 270 (65), 147 (100).

2-Hydroxyl-2-(1,2-dimethyl-indol-3-yl)-3,3,3-trifluoropropionic acid ethyl ester. ***(Table-2, Entry-7),*** Dark brown crystals. (m.p 83-84.5 ^oC), ^1H NMR (399.81 MHz, $CDCl_3$), d (ppm) 7.77 (d, *J* =7.99 Hz, 1H, Ar), 7.26 (d, *J*=8.3 Hz, 1H, Ar), 7.17 (ddd, *J*=6.7, 1.1 Hz, 1H, Ar), 7.08 (ddd, *J*=6.7, 1.1 Hz, 1H, Ar), 4.41 (dq, *J*=7.1, 3.1 Hz, 1H, CH_2), 4.39 (s, 1H, OH), 4.36 (dq, *J*=7.1, 3.1 Hz, 1H, CH_2), 3.65 (s, 3H, CH_3), 2.52 (s, 3H, CH_3), 1.35 (td, *J*=7.2, 3H, CH_3). ^{13}C NMR (100.54 MHz, $CDCl_3$), d (ppm) 169.5, 137.1, 136.6, 129.2, 125.9, 124.8, 122.7, 121.4, 120.2, 109.1, 103.7, 63.5, 29.6, 14.1, 11.8, ^{19}F NMR (376.15 MHz, $CDCl_3$, $CFCl_3$-Ref), d (ppm) -77.01 (s, 3F), MS-$C_{15}H_{16}F_3NO_3$ (315), m/z (%): 315 (M^+, 33), 242 (100), 172 (66), 145 (85).

2-Hydroxyl-2-(2-phenyl-indol-3-yl)-3,3,3-trifluoropropionic acid ethyl ester. ***(Table-2, Entry-8),*** Light green crystals. (m.p 145.0-147.0 ^oC), ^1H NMR (399.81 MHz,$CDCl_3$), d (ppm) 8.14 (bs, 1H, NH), 8.04 (d, *J*=8.0 Hz,1H, Ar), 7.43 (m, 5H, Ar), 7.32 (td, *J*=8.0, 1.2 Hz,1H, Ar), 7.23 (ddd, *J*=5.6, 1.2 Hz, 1H, Ar), 7.18 (ddd, *J*=7.2, 1.5 Hz, 1H, Ar), 3.88 (dq, *J*=10.4, 7.2 Hz,1H, CH_2), 3.72 (s,1H, OH), 3.50 (dq, *J*=14.4, 7.2 Hz, 1H, CH_2), 1.08 (t, *J*=7.2 Hz, 3H, CH_3). ^{13}C NMR (100.54 MHz, $CDCl_3$), d (ppm) 168.7, 138.0, 135.3, 132.7, 130.5, 129.2, 128.1, 126.7, 125.4, 123.0, 122.6, 122.5, 122.9, 110.8, 106.2, 63.1, 13.7, ^{19}F NMR (376.19 MHz, $CDCl_3$, $CFCl_3$-Ref), d (ppm) -75.63 (s, 3F), MS-$C_{19}H_{16}F_3NO_3$ (363), m/z (%): 363 (M^+, 15), 290 (66), 220 (50), 193 (100).

2-Hydroxyl-2-(1-methyl-indol-3-yl)-3,3,3-trifluoropropionic acid ethyl ester. ***(Table-2, Entry-9),*** Dark red crystals. (m.p 61-62.2 ^oC), ^1H NMR (399.81 MHz, $CDCl_3$), d (ppm) 7.87 (d, *J*=8.3 Hz, 1H, Ar), 7.31 (d, *J*=2.7 Hz, 1H, Ar), 7.29 (dd, *J*=1.5 Hz, 1H, Ar), 7.24 (ddd, *J*=6.7, 0.7 Hz, 1H, Ar), 7.14 (ddd, *J*=6.7, 1.1 Hz, 1H.Ar), 4.45 (dq, *J*=7.19, 3.5 Hz, 1H, CH_2), 4.39 (s, 1H, OH), 4.32 (dq, *J*=6.7, 3.5 Hz, 1H, CH_2), 3.77 (s, 3H, CH_3), 1.35 (td, *J*=7.2 Hz, 3H, CH_3). ^{13}C NMR (100.54 MHz, $CDCl_3$), d (ppm) 169.6, 137.4, 129, 125.9, 125.1, 122.4, 121.4, 120.3, 109.7, 107.0, 64.3, 33.2, 14.1, ^{19}F NMR (376.15 MHz, $CDCl_3$, $CFCl_3$-Ref), d (ppm) -77.17 (s, 3F), MS-$C_{14}H_{14}F_3NO_3$ (301), m/z (%): 301 (M^+, 25), 228 (100), 158 (60), 131 (80).

2-hydroxyl-2-(5-methyl-indol-3-yl)-3,3,3-trifluoropropionic acid ethyl ester. ***(Table-2, Entry-10),*** Light brown crystals. (m.p. 75.2-76.5 ^oC), ^1H NMR (399.81 MHz, $CDCl_3$), d (ppm) 8.16 (bs,

1H, NH), 7.66 (s, 1H, Ar), 7.40 (d, *J*=2.3 Hz, 1H, Ar), 7.24 (d, *J*=8.3 Hz, 1H, Ar), 7.03 (dd, *J*=8.3, 1.5 Hz, 1H, Ar), 4.43 (dq, *J*=7.19, 3.6 Hz, 1H, CH_2), 4.39 (s, 1H, OH), 4.34 (dq, *J*=7.19, 3.5 Hz, 1H, CH_2), 2.43 (s, 3H, CH_3), 1.35 (td, *J*=7.2 Hz, 3H, CH_3). ^{13}C NMR (100.53 MHz, $CDCl_3$), d (ppm) 169.6, 151.7, 134.8, 130.0, 125.6, 124.5, 123.4, 122.3, 120.9, 111.1, 108.4, 64.3, 21.8, 14.0, ^{19}F NMR (376.19 MHz, $CDCl_3$, $CFCl_3$-Ref), d (ppm) -77.12 (s, 3F), MS-$C_{14}H_{14}F_3NO_3$ (301), m/z (%): 301 (M^+, 11), 130 (100).

3-Hydroxyl-3-(indol-3-yl)-4,4,4-trifluorobutanoic acid ethyl ester. ***(Table-3, Entry-1)***, Green oil. ^{1}H NMR (399.81 MHz, $CDCl_3$), d (ppm) 8.21 (bs, 1H, NH), 7.88 (d, *J*=8 Hz, 1H, Ar), 7.35 (d, *J*=8.4 Hz, 1H, Ar), 7.28 (d, *J*=2.8 Hz, 1H, Ar), 7.20 (ddd, *J*=8.0, 1.2 Hz, 1H, Ar), 7.14 (ddd, *J*=7.2, 1.2 Hz, 1H, Ar), 5.36 (s, 1H, OH), 4.09 (m, 2H, CH_2), 3.28 (d, *J*=16.4 Hz, 1H, CH_2), 3.17 (d, *J*=16 Hz, 1H, CH_2), 1.13 (t, *J*=7.2 Hz, 3H, CH_3). ^{13}C NMR (100.5 MHz, $CDCl_3$), d (ppm) 171.8, 136.7, 126.7, 125.4, 123.8, 123.7, 122.7, 121.4, 120.5, 113.5, 111.5, 61.7, 38.5, 14.0, ^{19}F NMR (376.15 MHz, $CDCl_3$, $CFCl_3$-Ref), d (ppm) -81.15 (s, 3F), MS-$C_{14}H_{14}F_3NO_4$ (301), m/z (%): 301 (M^+, 25), 232 (30), 214 (25), 144 (100), 117 (10).

3-Hydroxyl-3-(5-iodo-indol-3-yl)-4,4,4-trifluorobutanoic acid ethyl ester. ***(Table-3, Entry-2)***, Dark green oil. ^{1}H NMR (399.81 MHz, $CDCl_3$), d (ppm) 8.32 (bs, 1H, NH), 7.45 (dd, *J*=8.4, 1.6 Hz, 1H, Ar), 7.32 (d, *J*=8.4 Hz, 1H, Ar), 7.21 (d, *J*=2.8 Hz, 1H, Ar), 7.10 (s, 1H, Ar), 5.39 (s, 1H, OH), 4.11 (m, 2H, CH_2), 3.20 (d, *J*=16.4 Hz, 1H, CH_2), 3.14 (d, *J*=16 Hz, 1H, CH_2), 1.16 (t, *J*=6.8 Hz, 3H, CH_3). ^{13}C NMR (100.5 MHz, $CDCl_3$), d (ppm) 169.3, 135.6, 131.2, 130.7, 129.8, 128.8, 125.3, 124.3, 113.4, 111.8, 112.5, 60.9, 40.1, 13.7, ^{19}F NMR (376.15 MHz, $CDCl_3$, $CFCl_3$-Ref), d (ppm) -81.20 (s, 3F), MS-$C_{14}H_{13}F_3INO_3$ (427), m/z (%): 427 (M^+, 25), 358 (55), 340 (10), 270 (100).

3-Hydroxyl-3-(2-methyl-indol-3-yl)-4,4,4-trifluorobutanoic acid ethyl ester. ***(Table-3, Entry-3)***, Light yellow oil. ^{1}H NMR (399.81 MHz, $CDCl_3$), d (ppm) 7.92 (bs, 1H, NH), 7.70 (d, *J*=8 Hz, 1H, Ar), 7.23 (dt, *J*=8.4, 0.8 Hz, 1H, Ar), 7.08 (m, 2H, Ar), 5.37 (s, 1H, OH), 4.062 (m, 2H, CH_2), 3.51 (d, *J*=16 Hz, 1H, CH_2), 3.23 (d, *J*=16 Hz, 1H, CH_2), 2.58 (s, 3H, CH_3), 1.08 (t, *J*=7.2 Hz, 3H, CH_3). ^{13}C NMR (100.5 MHz, $CDCl_3$), d (ppm) 172.1, 135.2, 135.0, 127.2, 127.0, 124.4, 121.4, 120.6, 120.2, 110.5, 107.4, 61.6, 38.8, 14.8, 13.0, ^{19}F NMR (376.15 MHz, $CDCl_3$, $CFCl_3$-Ref), d (ppm) -81.49 (s, 3F), MS-$C_{15}H_{16}F_3NO_3$ (315), m/z (%): 315 (M^+, 25), 246 (40), 228 (25), 158 (100), 131 (20).

3-Hydroxyl-3-(5-chloro-indol-3-yl)-4,4,4-trifluorobutanoic acid ethyl ester. ***(Table-3, Entry-4)***, Red oil. ^{1}H NMR (399.81 MHz, $CDCl_3$), d (ppm) 8.30 (bs, 1H, NH), 7.88 (s, 1H, Ar), 7.16 (d, *J*=6.8 Hz, 1H, Ar), 7.01 (d, *J*=7.6 Hz, 1H, Ar), 6.89 (s, 1H, Ar), 5.38 (s, 1H, OH), 4.11 (m, 2H, CH_2), 3.20 (d, *J*=16 Hz, 1H, CH_2), 3.14 (d, *J*=16 Hz, 1H, CH_2), 1.16 (t, *J*=7.2 Hz, 3H, CH_3). ^{13}C NMR (100.5 MHz, $CDCl_3$), d (ppm) 171.6, 134.9, 127.5, 126.4, 125.7, 124.9, 123.2, 122.7, 121.0, 120.4, 112.5, 61.8, 38.5, 14.0, ^{19}F NMR (376.15 MHz, $CDCl_3$, $CFCl_3$-Ref), d (ppm) -81.23 (s, 3F), MS-$C_{14}H_{13}F_3ClNO_3$ (335), m/z (%): 335 (M^+, 15), 266 (20), 248 (10), 178 (100), 151 (20).

3-Hydroxyl-3-(5-bromo-indol-3-yl)-4,4,4-trifluorobutanoic acid ethyl ester. ***(Table-3, Entry-5)***, Orange crystals. (m.p 89-90.1 ^{o}C), ^{1}H NMR (399.81 MHz, $CDCl_3$), d (ppm) 8.24 (bs, 1H, NH), 8.05 (s, 1H, Ar), 7.29 (d, *J*=1.2 Hz, 1H, Ar), 7.27 (d, *J*=3.6 Hz, 1H, Ar), 7.22 (d, *J*=8.8 Hz, 1H, Ar), 5.38 (s, 1H, OH), 4.11 (m, 2H, CH_2), 3.20 (d, *J*=16 Hz, 1H, CH_2), 3.14 (d, *J*=16 Hz, 1H, CH_2), 1.16 (t, *J*=7.2 Hz, 3H, CH_3). ^{13}C NMR (100.5 MHz, $CDCl_3$), d (ppm) 171.6, 161.0, 135.3, 127.1, 125.8, 124.6, 124.1, 118.7, 114.0, 113.3, 112.8, 61.8, 38.5, 14.0, ^{19}F NMR (376.15 MHz, $CDCl_3$, $CFCl_3$-Ref), d (ppm) -81.24 (s, 3F), MS-$C_{14}H_{13}F_3BrNO_3$ (380), m/z (%): 380 (M^+, 15), 310 (40), 292 (10), 224 (100).

3-Hydroxyl-3-(5-methoxy-indol-3-yl)-4,4,4-trifluorobutanoic acid ethyl ester. ***(Table-3, Entry-6)***, Red crystals. (m.p. 112-113.8 ^{o}C), ^{1}H NMR (399.81 MHz, $CDCl_3$), d (ppm) 8.11 (bs, 1H, NH), 7.37 (s, 1H, Ar), 7.23 (m, 2H, Ar), 6.87 (dd, *J*=8.4, 2.0 Hz, 1H, Ar), 5.33 (s, 1H, OH), 4.11 (m, 2H, CH_2), 3.85 (s, 3H, CH_3), 3.24 (d, *J*=16 Hz, 1H, CH_2), 3.14 (d, *J*=16 Hz, 1H, CH_2), 1.16 (t, *J*=6.8 Hz, 3H, CH_3). ^{13}C NMR (100.5 MHz, $CDCl_3$), d (ppm) 171.8, 154.5, 131.8, 126.1, 124.03, 113.1, 113.0, 112.5, 112.1, 111.8, 103.4, 61.7, 56.1, 38.5, 14.1, ^{19}F NMR (376.15 MHz, $CDCl_3$, $CFCl_3$-Ref), d (ppm) -81.14 (s, 3F), MS-$C_{15}H_{16}F_3NO_4$ (331), m/z (%): 331 (M^+, 15), 262 (25), 244 (25), 174 (100), 147 (20).

3-Hydroxyl-3-(1,2-dimethyl-indol-3-yl)-4,4,4-trifluorobutanoic acid ethyl ester. ***(Table-3, Entry-7)***, Yellow crystals. (m.p. 102.4-103.9 ^{o}C), ^{1}H NMR (399.81 MHz, $CDCl_3$), d (ppm) 7.68 (d, *J*=8 Hz, 1H, Ar), 7.23 (d, *J*=8 Hz, 1H, Ar), 7.23 (ddd, *J*=7.2, 1.2 Hz, 1H, Ar), 7.05 (ddd, *J*=7.2, 1.2 Hz, 1H, Ar), 5.37 (s, 1H, OH), 4.04 (m, 2H, CH_2), 3.64 (s, 3H, CH_3), 3.59 (d, *J*=16.4 Hz, 1H, CH_2), 3.24 (d, *J*=16 Hz, 1H, CH_2), 2.62 (s, 3H, CH_3), 1.07 (t, *J*=7.2 Hz, 3H, CH_3). ^{13}C NMR (100.5 MHz, $CDCl_3$), d (ppm) 172.2, 157.3, 137.0, 135.1, 125.9, 123.9, 122.9, 120.9, 120.3, 119.8, 109.1, 106.7, 61.5, 39.1, 29.6, 13.9, ^{19}F NMR (376.15 MHz, $CDCl_3$, $CFCl_3$-Ref), d

(ppm) -81.49 (s, 3F), MS-$C_{16}H_{18}F_3NO_3$ (329), m/z (%): 329 (M^+, 20), 260 (25), 242 (10), 172 (100), 145 (15).

3-Hydroxyl-3-(2-phenyl-indol-3-yl)-4,4,4-trifluorobutanoic acid ethyl ester. ***(Table-3, Entry-8)***, Colorless solid. (m.p. 206.7-208.1 ^oC), ^1H NMR (399.81 MHz, $CDCl_3$), d (ppm) 8.04 (bs, 1H, NH), 7.44 (m, 5H, Ar), 7.31 (s, 1H, Ar), 7.30 (d, *J*=1.2 Hz, 1H, Ar), 7.21 (ddd, *J*=6.4, 1.2 Hz, 1H, Ar), 7.16 (ddd, *J*=8.4, 1.2 Hz, 1H, Ar), 5.28 (s, 1H, OH), 3.90 (m, 2H, CH_2), 3.12 (d, *J*=16.8 Hz, 1H, CH_2), 2.90 (d, *J*=16.8 Hz, 1H, CH_2), 1.04 (t, *J*=7.2 Hz, 3H, CH_3). ^{13}C NMR (100.5 MHz, $CDCl_3$), d (ppm) 171.6, 136.9, 135.5, 133.8, 130.3, 129.2, 128.3, 127.4, 126.1, 123.7, 122.9, 122.7, 120.6, 115.3, 113.1, 110.7, 109.3, 61.2, 38.5, 13.9, ^{19}F NMR (376.15 MHz, $CDCl_3$, $CFCl_3$-Ref), d (ppm) -80.32 (s, 3F), MS-$C_{20}H_{18}F_3NO_3$ (377), m/z (%): 377 (M^+, 25), 308 (30), 290 (10), 220 (100), 193 (25).

3-Hydroxyl-3-(1-methyl-indol-3-yl)-4,4,4-trifluorobutanoic acid ethyl ester. ***(Table-3, Entry-9)***, Brown oil. ^1H NMR (399.81 MHz, $CDCl_3$), d (ppm) 7.85 (d, *J*=8 Hz, 1H, Ar), 7.29 (d, *J*=8 Hz, 1H, Ar), 7.23 (t, *J*=7.6 Hz, 1H, Ar), 7.15 (d, *J*=6.4 Hz, 1H, Ar), 7.12 (d, *J*=0.8 Hz, 1H, Ar), 5.33 (s, 1H, OH), 4.10 (m, 2H, CH_2), 3.76 (s, 3H, CH_3), 3.27 (d, *J*=16.0 Hz, 1H, CH_2), 3.17 (d, *J*=16.0 Hz, 1H, CH_2), 1.14 (t, *J*=7.2 Hz, 3H, CH_3). ^{13}C NMR (100.5 MHz, $CDCl_3$), d (ppm) 171.8, 137.6, 128.4, 125.9, 122.1, 121.6, 121.5, 120.1, 111.5, 109.7, 101.0, 61.6, 38.6, 33.1, 14.0, ^{19}F NMR (376.15 MHz, $CDCl_3$, $CFCl_3$-Ref), d (ppm) -81.21 (s, 3F), MS-$C_{15}H_{16}F_3NO_3$ (315), m/z (%): 315 (M^+, 15), 246 (15), 228 (25), 158 (100), 131 (15).

3-Hydroxyl-3-(5-methyl-indol-3-yl)-4,4,4-trifluorobutanoic acid ethyl ester. ***(Table-3, Entry-10)***, Grey oil. ^1H NMR (399.81 MHz, $CDCl_3$), d (ppm) 8.10 (bs, 1H, NH), 7.66 (s, 1H, Ar), 7.23 (m, 2H, Ar), 7.03 (d, *J*=6.8 Hz, 1H, Ar), 5.34 (s, 1H, OH), 4.10 (m, 2H, CH_2), 3.25 (d, *J*=15.6 Hz, 1H, CH_2), 3.16 (d, *J*=15.6 Hz, 1H, CH_2), 2.44 (s, 3H, CH_3), 1.15 (t, *J*=6.8 Hz, 3H, CH_3). ^{13}C NMR (100.5 MHz, $CDCl_3$), d (ppm) 171.8, 135.1, 129.8, 125.9, 125.7, 124.3, 123.7, 121.0, 113.5, 111.1, 106.5, 61.7, 38.6, 21.8, 14.0, ^{19}F NMR (376.15 MHz, $CDCl_3$, $CFCl_3$-Ref), d (ppm) -81.10 (s, 3F), MS-$C_{15}H_{16}F_3NO_3$ (315), m/z (%): 315 (M^+, 25), 246 (40), 228 (25), 158 (100), 131 (20).

2-Hydroxyl-2-(pyrrol-2-yl)-3,3,3-trifluoropropionic acid ethyl ester. ***(Table-4, Entry-1)***, Orange oil. ^1H NMR (399.81 MHz, $CDCl_3$), d (ppm) 8.75 (bs, 1H, NH), 6.81 (ddd, *J* = 2.8, 1.6 Hz, 1H, Ar), 6.44 (ddd, *J* = 2.8, 1.2 Hz, 1H, Ar), 6.21 (q, *J* = 6.4, 2.8 Hz, 1H, Ar), 4.45 (dq, *J* = 7.2, 3.6 Hz, 1H, CH_2), 4.41 (s, 1H, OH), 4.37 (dq, *J* = 7.2, 3.6 Hz, 1H, CH_2), 1.37 (t, *J* = 7.2 Hz,

3H, CH_3), ^{13}C NMR (100.53 MHz, $CDCl_3$), d (ppm) 168.2, 124.1, 121.9, 119.0, 110.1, 109.5, 109.1, 64.7, 14.0, ^{19}F NMR (376.15 MHz, $CDCl_3$, $CFCl_3$-Ref), d (ppm) -78.87 (s, 3F),MS-$C_9H_{10}F_3NO_3$ (237), m/z (%): 237 (M^+, 20), 164 (80), 94 (100).

2-Hydroxyl-2-(1-methyl-pyrrol-2-yl)-3,3,3-trifluoropropionic acid ethyl ester. ***(Table-4, Entry-2)***, Light yellow oil.^1H NMR (399.81 MHz, $CDCl_3$), d (ppm) 6.61 (q, *J* = 2.8, 2.0 Hz, 1H, Ar), 6.38 (td, *J* = 3.4, 1.6 Hz, 1H, Ar), 6.06 (dd, *J* = 3.6, 2.4 Hz, 1H, Ar), 4.46 (dq, *J* = 6.8, 3.2 Hz, 1H, CH_2), 4.36 (dq, *J* = 6.8, 3.2 Hz, 1H, CH_2), 4.29 (s, 1H, OH), 3.59 (s, 3H, CH_3), 1.35 (t, *J* = 7.2 Hz, 3H, CH_3).^{13}C NMR (100.53 MHz, $CDCl_3$), d (ppm) 169.0, 126.2, 124.5, 122.4, 121.7, 111.5, 107.1, 64.7, 36.0, 14.0; ^{19}F NMR (376.15 MHz, $CFCl_3$-Ref), d (ppm) -75.95 (s, 3F). MS-$C_{10}H_{12}F_3NO_3$ (251), m/z (%): 251 (M^+, 15), 178 (80), 108 (100).

2-hydroxyl-2-(3,5-dimethyl-pyrrol-2-yl)-3,3,3-trifluoropropionic acid ethyl ester. ***(Table-4, Entry-3)***, Dark brown oil. ^1H NMR (399.81 MHz, $CDCl_3$), d (ppm) 8.38 (bs, 1H, NH), 5.69 (s, 1H, Ar), 4.43 (dq, *J* = 7.2, 1.2 Hz, 1H, CH_2), 4.39 (dq, *J* = 7.2, 3.6 Hz, 1H, CH_2), 4.24 (s, 1H, OH), 2.28 (s, 3H, CH_3), 2.18 (s, 3H, CH_3), 1.32 (t, *J* = 6.8 Hz, 3H, CH_3), ^{13}C NMR (100.53 MHz, $CDCl_3$), d (ppm) 169.6, 127.7, 121.9, 119.9, 115.6, 114.9, 111.5, 64.8, 64.5, 63.3, 14.0, ^{19}F NMR (376.15 MHz, $CDCl_3$, $CFCl_3$-Ref), d (ppm) -77.79 (s, 3F), MS-$C_9H_{10}F_3NO_3$ (265), m/z (%): 265 (M^+, 30), 192 (100), 122 (80).

2-Hydroxyl-2-(5-ethyl-pyrrol-2-yl)-3,3,3-trifluoropropionic acid ethyl ester. ***(Table-4, Entry-4)***, Dark brown thick oil. ^1H NMR (399.81 MHz, $CDCl_3$), d (ppm) 8.38 (bs, 1H, NH), 6.31 (t, *J*=2.8 Hz, 1H, Ar), 5.89 (t, *J*=3.6 Hz, 1H, Ar), 4.42 (dq, *J* =7.2, 3.6 Hz, 1H, CH_2), 4.39 (s, 1H, OH), 4.36 (dq, *J* = 7.2, 1.2 Hz, 1H, CH_2), 2.60 (q, *J*=8 Hz, 2H, CH_2), 1.37 (t, *J* = 7.2 Hz, 3H, CH_3), 1.22 (t, *J* = 8.0 Hz, 3H, CH_3), ^{13}C NMR (100.53 MHz, $CDCl_3$), d (ppm) 168.3, 135.6, 122.2, 121.3, 120.0, 109.7, 105.7, 64.6, 20.9, 14.0, 13.4, ^{19}F NMR (376.15 MHz, $CDCl_3$, $CFCl_3$-Ref), d (ppm) -78.82 (s, 3F), MS-$C_{11}H_{14}F_3NO_3$ (265), m/z (%): 265 (M^+, 30), 192 (100), 122 (80).

3-Hydroxyl-3-(pyrrol-2-yl)-4,4,4-trifluorobutanoic acid ethyl ester. ***(Table-4, Entry-5)***, Green oil. ^1H NMR (399.81 MHz, $CDCl_3$), d (ppm) 8.75 (bs, 1H, NH), 6.79 (q, *J* = 4.0, 2.4, Hz, 1H, Ar), 6.16 (dd, *J* = 6.0, 2.8 Hz, 1H, Ar), 6.12 (t, *J*=3.6, 1H, Ar), 5.58 (s, 1H, OH), 4.16 (m, 2H, CH_2), 3.07 (d, *J*=16.0 Hz, 1H, CH_2), 3.01 (d, *J*=16.0 Hz, 1H, CH_2), 1.23 (t, *J* = 7.2 Hz, 3H, CH_3), ^{13}C NMR (100.53 MHz, $CDCl_3$), d (ppm) 172.0, 126.8, 124.8, 122.8, 118.8, 109.1, 107.0,

62.0, 37.5, 14.1, ^{19}F NMR (376.15 MHz, $CDCl_3$, $CFCl_3$-Ref), d (ppm) -81.97 (s, 3F), MS-$C_{10}H_{13}F_3NO_3$ (251), m/z (%): 251 (M^+, 40), 182 (70), 164 (80), 94 (100).

3-Hydroxyl-3-(1-methyl-pyrrol-2-yl)-4,4,4-trifluorobutanoic acid ethyl ester. ***(Table-4, Entry-6)***, Grey oil. ^1H NMR (399.81 MHz, $CDCl_3$), d (ppm) 6.59 (t, *J*=7.2 Hz, 1H, Ar), 6.08 (t, *J*=3.4 Hz, 1H, Ar), 6.01 (dd, *J*=3.6, 2.4 Hz, 1H, Ar), 5.52 (s, 1H, OH), 4.17 (m, 2H, CH_2), 3.82 (s, 3H, CH_3), 3.18 (d, *J*=16.0 Hz, 1H, CH_2), 2.96 (d, *J*=16.0 Hz, 1H, CH_2), 1.25 (t, *J* = 7.2 Hz, 3H, CH_3), ^{13}C NMR (100.53 MHz, $CDCl_3$), d (ppm) 172.3, 126.6, 126.1, 123.2, 114.1, 110.2, 106.9, 61.9, 38.2, 37.0, 14.1, ^{19}F NMR (376.15 MHz, $CDCl_3$, $CFCl_3$-Ref), d (ppm) -80.44 (s, 3F), MS-$C_{11}H_{14}F_3NO_3$ (265), m/z (%): 265 (M^+, 30), 196 (60), 178 (80), 108 (100), 81 (10).

3-hydroxyl-3-(3,5-dimethyl-pyrrol-2-yl)-4,4,4-trifluorobutanoic acid ethyl ester. ***(Table-4, Entry-7)***, Black oil. ^1H NMR (399.81 MHz, $CDCl_3$), d (ppm) 8.27 (bs, 1H, NH), 6.71 (d, *J*=3.2 Hz, 1H, Ar), 5.64 (s, 1H, OH), 4.16 (q, *J*=14.0, 6.8 Hz, 1H, Ar), 3.21 (d, *J*=16.0 Hz, 1H, CH_2), 3.03 (d, *J*=16.4 Hz, 1H, CH_2), 2.17 (s, 3H, CH_3), 2.06 (s, 3H, CH_3), 1.21 (t, *J* = 7.2 Hz, 3H, CH_3), ^{13}C NMR (100.53 MHz, $CDCl_3$), d (ppm) 172.0, 126.8, 123.4, 119.8, 118.1, 116.5, 110.7, 73.4, 61.9, 36.8, 36.5, 14.0, ^{19}F NMR (376.15 MHz, $CDCl_3$, $CFCl_3$-Ref), d (ppm) -81.73 (s, 3F), MS-$C_{12}H_{16}F_3NO_3$ (279), m/z (%): 279 (M^+, 25), 210 (30), 192 (60), 122 (100).

3-hydroxyl-3-(5-ethyl-pyrrol-2-yl)-4,4,4-trifluorobutanoic acid ethyl ester. ***(Table-4, Entry-8)***, Red oil. ^1H NMR (399.81 MHz, $CDCl_3$), d (ppm) 8.35 (bs, 1H, NH), 6.70 (t, *J*=3.6 Hz, 1H, Ar), 6.06 (t, *J*=3.1 Hz, 1H, Ar), 5.53 (s, 1H, OH), 4.16 (q, *J*=14.4, 7.2 Hz, 2H, CH_2), 4.1 (m, 2H, CH_2), 2.71 (q, *J*=16.4, 7.2 Hz, 2H, CH_2), 1.32 (t, *J*=7.2 Hz, 3H, CH_3), 1.29 (t, *J*=7.60 Hz, 3H, CH_3), ^{13}C NMR (100.53 MHz, $CDCl_3$), d (ppm) 166.0, 141.5, 122.7, 118.4, 108.5, 105.1, 104.5, 99.5, 61.6, 21.5, 14.3, 13.1, ^{19}F NMR (376.15 MHz, $CDCl_3$, $CFCl_3$-Ref), d (ppm) -81.91 (s, 3F), MS-$C_{12}H_{16}F_3NO_3$ (279), m/z (%): 279 (M^+, 25), 210 (30), 192 (35), 122 (100).