Supporting Information

Nucleophilic Fluoroalkylation of Epoxides with Fluorinated Sulfones

Chuanfa Ni, Ya Li, and Jinbo Hu*

Key Laboratory of Organofluorine Chemistry, Shanghai Institute of Organic Chemistry, Chinese Academy of Sciences, 354 Fenglin Rd., Shanghai 200032, China

jinbohu@mail.sioc.ac.cn

Table of Contents

• General Remarks	S 2
• Characterization data for the isolated new compounds	S 3 -13
• References	S 13
• NMR spectra for all products	S 14 - 73

General Remarks: Unless otherwise mentioned, all chemicals were purchased from commercial sources. THF, Et₂O was freshly distilled over sodium. Silica gel (300-400 mesh) was used for column chromatography, and in most cases petroleum ether/ethyl acetate combination was used as the eluent. ¹H, ¹³C and ¹⁹F NMR spectra were recorded on 500 MHz, 400 MHz or 300 MHz NMR spectrometer. ¹H NMR chemical shifts were determined relative to internal (CH₃)₄Si (TMS) at δ 0.0 or to the signal of a residual protonated solvent: CDCl₃ δ 7.26. ¹³C NMR chemical shifts were determined relative to internal TMS at δ 0.0. ¹⁹F NMR chemical shifts were determined relative to CFCI₃ at δ 0.0.

The starting materials dichloromethyl phenyl sulfone¹, fluoromethyl phenyl sulfone **8**², and aziridine **20**³ were prepared according to the known procedures. Chloromethyl phenyl sulfone was prepared from the oxidation of chloromethyl phenyl sulfide with mCPBA. The epoxides were prepared by using the following three approaches with commercially available alkenes or carbonyl compounds:

1) The following epoxides were prepared by oxidation of the corresponding alkenes with mCPBA⁴:

2) The following epoxides were prepared from aromatic aldehydes and trimethylsulfonium iodide in CH₃CN using NaOH as the base⁵ □

3) The following epoxides were prepared from ketones and trimethylsulfonium iodide in DMSO according to Corey's procedure⁶:

Characterization data for the isolated new compounds:

1-Benzenesulfonyl-1,1-dichloro-3-(4'-chlorophenyl)-3-propanol (6b).

73% yield, white solid, m.p. 88–89°C.

¹H NMR (CDCl₃): δ 2.79 (d, *J* = 3.4 Hz, 1H), 2.90–3.10 (m, 2H), 5.35 (dt, *J* = 7.9, 2.6 Hz, 1H), 7.35 (m, 4H), 7.60–7.66 (m, 2H), 7.76–7.81 (m, 1H), 8.08–8.11 (m, 2H). ¹³C NMR (CDCl₃): δ 48.9, 70.3, 97.9, 127.3, 128.9, 129.0, 131.3, 132.5, 133.8, 135.5, 141.4. **MS**(EI, *m/z*): 380, 363, 236, 219, 201, 141, 113, 77. **HRMS** (MALDI): *m/z* calcd for C₁₅H₁₃Cl₃O₃SNa (M+Na⁺) 400.9549, found 400.9543. IR (KBr): 3539, 3063, 2922, 1490, 1449, 1336, 1325, 1316, 1159.

1-(2'-Benzenesulfonyl-2',2'-dichloroethyl)cyclohexanol (6c):

75% yield, white crystals, m.p. 96–98 °C.

^1H NMR (CDCl_3): δ 1.20–1.80 (m, 8H), 1.80–1.95 (m, 2H), 2.05 (br, 1H), 2.80 (s, 2H), 7.57–7.66 (m, 2H), 7.73–7.80 (m, 1H), 8.06–8.12 (m, 2H). ^{13}C NMR (CDCl_3): δ 21.7, 25.3, 38.6, 48.2, 72.5, 97.9, 128.7, 131.2, 132.7, 135.2. MS (EI, m/z): 319 ($\text{M}^+ - \text{H}_2\text{O}$), 195, 177, 151, 143, 125, 99. EA calcd. for $\text{C}_{14}\text{H}_{18}\text{Cl}_2\text{O}_3\text{S}$: C, 49.86; H, 5.38; Found C, 49.66; H, 5.38. IR (KBr): 3532, 3452, 2928, 2850, 1451, 1312, 1150, 1081, 1022.

1-(2'-Benzenesulfonyl-2',2'-dichloroethyl)cyclooctanol (6d):

80% yield, white crystals, M.p. 115–116°C.

^1H NMR (CDCl_3): δ 1.40–2.00 (m, 14H), 2.05 (s, 1H), 2.80 (s, 2H), 7.57–7.66 (m, 2H), 7.73–7.80 (m, 1H), 8.06–8.12 (m, 2H). ^{13}C NMR (CDCl_3): δ 22.0, 24.9, 28.0, 36.8, 46.3, 76.2, 99.1, 98.1, 128.7, 131.2, 132.7, 135.1. MS (EI, m/z): 347 ($\text{M} - \text{OH}$), 293, 223, 143, 127, 109. EA calcd. for $\text{C}_{16}\text{H}_{22}\text{Cl}_2\text{O}_3\text{S}$: C, 52.60; H, 6.07; Found C, 52.40; H, 6.07. IR (KBr): 3532, 3452, 2928, 2850, 1451, 1312, 1150, 1081, 1022.

2-Benzenesulfonyldichloromethyl cyclohexanol (6e):

84% yield, white crystals, m.p. 137–139 °C. ^1H NMR (CDCl_3): δ 1.20–1.60 (m, 4H), 1.73–1.89 (m, 2H), 2.07–2.22 (m, 1H), 2.40–2.55 (m, 1H), 2.60–2.75 (m, 1H), 3.76 (br, 1H), 7.55–7.65 (m, 2H), 7.68–7.76 (m, 1H), 8.08–8.15 (m, 2H). ^{13}C NMR (CDCl_3): δ 24.2, 25.4, 28.5, 34.9, 56.3, 70.8, 104.2, 128.7, 132.4, 132.8, 135.1. MS (EI, m/z): 297 (M–OH), 173, 143, 127, 109. EA calcd. For $\text{C}_{13}\text{H}_{16}\text{Cl}_2\text{O}_3\text{S}$: C, 48.31; H, 4.99; Found C, 48.16; H, 4.86. IR (KBr): 3531, 2938, 2854, 1449, 1327, 1315, 1159, 1150, 1083.

1-Benzenesulfonyl-1-fluoro-3-heptanol (10b).

68% yield, colorless oil. Two stereoisomers in 1:1 ratio.

^1H NMR (CDCl_3): δ 0.90 (m, 6H), 1.20–1.82 (m, 12H), 1.91–2.51 (m, 6H), 3.83 (m, 0.5H), 4.03 (m, 0.5H), 5.30–5.52 (ddm, $J = 48, 10$ Hz, 0.5H), 5.36–5.59 (ddm, $J = 49, 10.5$ Hz, 0.5H), 7.50–8.03 (m, 10H). ^{19}F NMR (CDCl_3): δ –175 (ddd, $J = 48.5, 28.0, 17.6$ Hz); δ –181.2 (ddd, $J = 49, 37, 14.5$ Hz). ^{13}C NMR (CDCl_3): δ 13.9 (C-7), 22.5/22.6 (C-6), 27.5/27.6 (C-5), 34.7/35.3 (d, $J = 18$ Hz, C-2), 37.0/37.8 (C-4), 66.8/68.2 (d, $J = 3.5$ Hz, C-3), 100.4/101.0 (d, $J = 216$ Hz, C-1), 128.9–135.6 (Ar-C for both stereoisomers). MS (EI, m/z): 275 ($\text{M}^+ + 1$), 257, 229, 157, 143, 125, 109. HRMS (MALDI): m/z calcd for $\text{C}_{13}\text{H}_{19}\text{FSO}_3\text{Na}$ ($\text{M} + \text{Na}^+$) 297.09366, found 255.09312. IR (film): 3396, 2957, 2932, 2861,

1709, 1448, 1325, 1152, 1085.

1-Benzenesulfonyl-1-fluoro-3-phenyl-3-propanol (10c).

46% yield, yellow solid, m.p. 60–63 °C. Two stereoisomers in 1:1.1 ratio.

^1H NMR (CDCl_3): δ 2.05–2.72(m, 3H), 4.83–5.71(m, 2H), 7.26–7.43 (m, 5H), 7.53–8.02 (m, 5H). ^{19}F NMR (CDCl_3): δ –177 (ddd, $J = 47.7, 28.5, 16.7$ Hz); δ –181.7 (ddd, $J = 49.6, 37.5, 12.4$ Hz). ^{13}C NMR (CDCl_3): δ 36.6/37.2(d, $J = 18$ Hz, C-2), 68.7/70.4(d, $J = 3.5$ Hz, C-3), 100.2(d, $J = 212$ Hz, C-1), 100.6(d, $J = 217$ Hz, C-1'), 125.5–143.0 (Ar-C for both stereoisomers). MS (EI, m/z): 294 (M^+), 277, 248, 191, 152, 143, 135, 107. HRMS (MALDI): m/z calcd for $\text{C}_{15}\text{H}_{15}\text{FSO}_3\text{Na}$ ($\text{M}+\text{Na}^+$) 317.0624, found 317.0618. IR(film): 3530, 3070, 2930, 1450, 1330, 1310, 1160, 1085, 1060.

1-(2'-Benzenesulfonyl-2'-fluoroethyl)cyclohexanol (10e):

30% yield, white powder, m.p. 75–77°C.

^1H NMR (CDCl_3): δ 1.10–1.80 (m, 11H), 1.88–2.35 (m, 2H), 5.35–5.57 (ddd, $J = 50, 7.2, 1.5$ Hz, 1H), 7.47–7.57 (m, 2H), 7.60–7.68 (m, 1H), 7.84–7.91 (m, 2H). ^{19}F NMR (CDCl_3): δ –173.4 (ddd, $J = 50, 42, 20$ Hz, 1F). ^{13}C NMR (CDCl_3): δ 21.9(d, $J = 21$ Hz), 25.2, 36.7, 38.9 (d, $J = 18$ Hz), 70.2, 100.6(d, $J = 216$ Hz), 129.2, 129.5, 134.5, 135.4. MS

(EI, m/z): 269 (M–OH), 181, 143, 125, 99. HRMS (MALDI): m/z calcd for $C_{14}H_{19}FSO_3Na$ (M+Na⁺) 309.0936, found 309.0931. IR(KBr): 3489, 3410, 3065, 2941, 2854, 1449, 1403, 1322, 1312, 1153.

1-(2'-Benzenesulfonyl-2'-fluoroethyl)cyclooctanol (10f):

.

19% yield, white powder, M.p. 76–78°C.

¹H NMR (CDCl₃): δ 1.20–1.95 (m, 15H), 2.00–2.43 (m, 2H), 5.38–5.65 (ddd, $J = 50, 9.0, 1.5$ Hz, 1H), 7.55–7.65 (t, $J = 7.9$ Hz, 2H), 7.68–7.76 (m, 1H), 7.92–8.00 (d, $J = 7.9$ Hz, 2H). ¹⁹F NMR (CDCl₃): δ –173.9 (ddd, $J = 50, 40, 21$ Hz, 1F). ¹³C NMR (CDCl₃): δ 21.9, 22.1, 24.9, 27.8, 28.1, 34.9, 37.9 (d, $J = 18$ Hz), 73.7, 100.6 (d, $J = 215$ Hz), 129.2, 129.5, 134.5, 135.5. MS (EI, m/z): 297 (M–OH), 173, 143, 127, 109. HRMS (MALDI): m/z calcd for $C_{16}H_{23}FSO_3Na$ (M+Na⁺) 337.1250, found 337.1244. IR(KBr): 3504, 3065, 2919, 1479, 1449, 1320, 1311, 1252, 1153.

2-Benzenesulfonylfluoromethyl cyclohexanol (10g)

48% yield, colorless oil. Two stereoisomers in 1:1.1 ratio.

¹H NMR (CDCl₃): δ 1.10–2.40 (m, 10H), 3.30–4.10 (m, 1H), 5.11–5.84 (m, 1H),

7.45–8.00 (m, 5H). ^{19}F NMR (CDCl_3): δ –184.8 (dd, $J = 50, 18$ Hz); δ –193.2 (dd, $J = 48, 30$ Hz). MS (EI, m/z): 273 ($\text{M}+\text{H}^+$), 255, 143, 125, 113. The ^{13}C NMR spectra was so complicated owing to the coexistence of all the isomers that we could not attribute the peaks.

HRMS (MALDI): m/z calcd for $\text{C}_{13}\text{H}_{17}\text{FSO}_3\text{Na}$ ($\text{M}+\text{Na}^+$) 295.0780, found 295.0774.

IR(film): 3515(br), 2920, 2880, 1450, 1320, 1310, 1290, 1160, 1052.

1-Benzenesulfonyl-1-chloro-3-butanol (15a)

71% yield, white solid. Two stereoisomers were obtained in a 2.7:1 ratio. M.p. 83–85°C.

^1H NMR (CDCl_3): δ 1.22–1.31 (m, 3H), 1.82–2.02 (m, 2H), 2.36–2.53 (m, 1H), 4.05 (m, 1H), 4.90–5.10 (m, 1H), 7.50–8.00 (m, 5H). ^{13}C NMR (CDCl_3): δ 24.1, 39.2, 63.8, 72.3, 129.2, 130.0, 135.2. MS (EI, m/z): 249($\text{M}+\text{H}^+$), 231, 186, 169, 142, 125. Elemental Analysis: calcd. for $\text{C}_{10}\text{H}_{13}\text{ClO}_3\text{S}$: C, 48.29; H, 5.27; found C, 48.27; H, 5.32. IR (film): 3535, 2968, 2936, 1448, 1396, 1307, 1293, 1147, 1125, 1082.

1-(2'-Benzenesulfonyl-2'-chloroethyl)cyclohexanol (15b):

67% yield, white solid, m.p. 87–89°C. Two stereoisomers in 1:1.12 ratio.

^1H NMR (CDCl_3): δ 1.15–1.80 (m, 10H), 1.99(s, 1H), 2.06/2.12 (d, $J = 8.5$ Hz, 1H), 2.64/2.69 (d, $J = 2.0$ Hz, 1H), 5.02/5.05 (d, $J = 2.0$ Hz, 1H), 7.55–7.64 (m, 2H), 7.67–7.75(m, 1H), 7.94–8.01(m, 2H). ^{13}C NMR (CDCl_3): δ 21.9, 22.0, 25.3, 36.8, 38.9, 42.4, 70.2, 70.6, 129.1, 129.9, 134.4, 135.1. MS (EI, m/z): 302(M^+), 285($\text{M}-\text{OH}$), 259, 161, 143, 125, 99, 81. HRMS (MALDI): m/z calcd for $\text{C}_{14}\text{H}_{19}^{35}\text{ClO}_3\text{SNa}$ ($\text{M}+\text{Na}^+$) 325.0641, found 325.0635.

IR(film): 3480, 3420, 2939, 2868, 1585, 1448, 1408, 1311, 1155.

2-Benzenesulfonylchloromethyl cyclohexanol (15c):

60% yield, white solid, m.p. 154–156°C.

^1H NMR (CDCl_3): δ 1.25–2.60 (m, 10H), 3.45(m, 1H), 5.34(s, 1H), 7.57(t, $J = 7.9$ Hz, 2H), 7.69(m, 1H), 7.96(d, $J = 7.9$ Hz, 2H). ^{13}C NMR (CDCl_3): δ 24.5, 24.6, 24.9, 36.0, 44.9, 69.7, 74.8, 129.1, 129.4, 134.3, 137.1. MS (EI, m/z): 289($\text{M}+\text{H}^+$), 271, 143, 129, 93, 77. EA calcd. for $\text{C}_{13}\text{H}_{17}\text{ClO}_3\text{S}$: C, 54.07; H, 5.93; Found C, 53.95; H, 5.89. IR(film): 3520, 2935, 1451, 1306, 1292, 1278, 1151.

1,1-Bis(benzenesulfonyl)-1-fluoro-3-butanol (20a)

91% yield, colorless oil.

^1H NMR (CDCl_3): δ 1.17 (d, $J = 6.5$ Hz, 3H), 2.30–2.70 (m, 2H), 2.90 (s, 1H), 4.47 (m, 1H), 7.51–7.58 (m, 4H), 7.69–7.76 (m, 2H), 7.86–7.90 (m, 4H). ^{19}F NMR (CDCl_3): δ –168.2 (d, $J = 45.8$ Hz, 1F). ^{13}C NMR (CDCl_3): δ 23.9, 39.7 (d, $J = 16$ Hz), 62.9 (d, $J = 6$ Hz), 115.5 (d, $J = 265$ Hz), 129.22, 129.24, 130.8 (d, $J = 1$ Hz), 130.9, 134.5, 134.7, 135.5, 135.6. MS (ESI, m/z): 410.8($\text{M}+\text{K}^+$), 394.8($\text{M}+\text{Na}^+$). HRMS (MALDI): m/z calcd for $\text{C}_{16}\text{H}_{17}\text{FO}_5\text{S}_2\text{Na}$ ($\text{M}+\text{Na}^+$) 395.0399, found 395.0394. IR (film): 3557, 3067, 2976, 2932, 1449, 1341, 1153, 1077.

1,1-Bis(benzenesulfonyl)-1-fluoro-3-heptanol (20b).

89% yield, colorless oil.

^1H NMR (CDCl_3): δ 0.86(t, $J = 6.8$ Hz, 3H), 1.16–1.5(m, 3H), 2.30–2.70(m, 2H), 2.85 (s, 1H), 4.25 (m, 1H), 7.50–7.63 (m, 4H), 7.67–7.78 (m, 2H), 7.84–7.99 (m, 4H). ^{19}F NMR (CDCl_3): δ –142.6 (t, $J = 19$ Hz, 1F). ^{13}C NMR (CDCl_3): δ 14.0, 22.4, 27.4, 37.4, 38.6 (d, $J = 16$ Hz), 66.3 (d, $J = 5$ Hz), 115.6 (d, $J = 266$ Hz), 129.17, 129.20, 130.8 (d, $J = 1$ Hz), 131.0, 134.6, 134.8, 135.4, 135.5. MS (ESI, m/z): 432($\text{M}+\text{NH}_4^+$), 397($\text{M}+\text{H}^+-\text{H}_2\text{O}$). HRMS (MALDI): m/z calcd for $\text{C}_{19}\text{H}_{23}\text{FO}_5\text{S}_2\text{Na}$ ($\text{M}+\text{Na}^+$) 437.0869, found 437.0863. IR(film): 3563, 3067, 2932, 2861, 1583, 1450.

1,1-Bis(benzenesulfonyl)-1-fluoro-3-phenyl-3-propanol (20c).

37% yield □ pale yellow solid, m.p. 98–100°C.

^1H NMR (CDCl_3): δ 2.70–2.88 (m, 2H), 3.06 (d, $J = 2.7$ Hz, 1H), 5.38 (dt, $J = 8.9, 2.6$ Hz, 1H), 7.25–7.32 (m, 5H), 7.53–7.60 (m, 4H), 7.70–7.78 (m, 2H), 7.87–7.95 (m, 4H). ^{19}F NMR (CDCl_3): δ –142.9 (dd, $J = 22, 13.8$ Hz, 1F). ^{13}C NMR (CDCl_3): δ 40.5 (d, $J = 15$ Hz), 68.7 (d, $J = 6$ Hz), 115.0 (d, $J = 268$ Hz), 125.5, 127.9, 128.6, 129.20, 129.24, 130.9 (d, $J = 1.5$ Hz), 131.1, 134.4, 134.8, 135.52, 135.58, 142.8. MS (ESI, m/z): 473.0($\text{M}+\text{K}^+$), 457.0($\text{M}+\text{Na}^+$). HRMS (MALDI): m/z calcd for $\text{C}_{21}\text{H}_{19}\text{FO}_5\text{S}_2\text{Na}$ ($\text{M}+\text{Na}^+$) 457.0555, found 457.0550.

IR(film): 3550, 3175, 2920, 1449, 1341, 1152, 1079

3,3-Bis(benzenesulfonyl)-3-fluoro-2-phenylpropanol (20d).

33% yield □ pale yellow oil.

^1H NMR (CDCl_3): δ 2.31 (s, 1H), 4.01–4.08 (m, 2H), 4.60 (dm, $J = 60$ Hz, 1H), 7.10–7.80 (m, 15H). ^{19}F NMR (CDCl_3): δ –129.8 (d, $J = 9.2$ Hz, 1F). ^{13}C NMR (CDCl_3): δ 52.3 (d, $J = 17$ Hz), 61.4 (d, $J = 3$ Hz), 115.7 (d, $J = 266$ Hz), 128.2–136.6 (m, Ar-C). MS (ESI, m/z): 473.0($\text{M}+\text{K}^+$), 457.0($\text{M}+\text{Na}^+$). HRMS (MALDI): m/z calcd for $\text{C}_{21}\text{H}_{19}\text{FO}_5\text{S}_2\text{Na}$ ($\text{M}+\text{Na}^+$) 457.0555, found 457.0550.

IR(film): 3565, 3075, 2920, 1448, 1340, 1170, 1150, 1078

1-(2',2'-Bisbenzenesulfonyl-2'-fluoroethyl)cyclohexanol (20e):

87% yield □ white crystals, m.p. 138–140°C.

^1H NMR (CDCl_3): δ 1.25–1.64 (m, 11H), 2.65 (d, $J = 17$ Hz, 2H), 7.52–7.58 (m, 4H), 7.70–7.75 (m, 2H), 7.87–7.95 (m, 4H). ^{19}F NMR (CDCl_3): δ –146.5 (t, $J = 16.5$ Hz, 1F). ^{13}C NMR (CDCl_3): δ 21.9, 25.3, 38.7(d, $J = 2.3$ Hz), 39.8 (d, $J = 16$ Hz), 71.0(d, $J = 1.4$ Hz), 117.0 (d, $J = 274$ Hz), 129.0, 131.1 (d, $J = 1.4$ Hz), 134.4, 135.4. MS (EI, m/z): 285($\text{M}^+ - \text{PhSO}_2$), 265, 241, 187, 143, 125.

EA calcd. for $\text{C}_{20}\text{H}_{23}\text{FO}_5\text{S}_2$: C, 56.32; H, 5.44; found C, 56.12; H, 5.38.

IR(KBr): 3563, 2949, 2937, 2848, 1450, 1348, 1330, 1165, 1147, 1074.

1-(2',2'-Bisbenzenesulfonyl-2'-fluoroethyl)cyclooctanol (20f):

72% yield □ white crystals, m.p. 125–127°C.

^1H NMR (CDCl_3): δ 1.25–1.81 (m, 14H), 2.70 (d, $J = 17$ Hz, 2H), 2.81(s, 1H), 7.52–7.57 (m, 4H), 7.69–7.75 (m, 2H), 7.87–7.95 (d, $J = 7.9$ Hz, 4H). ^{19}F NMR (CDCl_3): δ –146.4 (d, $J = 17.2$ Hz, 1F). ^{13}C NMR (CDCl_3): δ 22.1, 25.1, 27.9, 37.2(d, $J = 2.1$ Hz), 38.2 (d, $J = 16$ Hz), 74.6, 117.2 (d, $J = 274$ Hz), 129.1, 131.1 (d, $J = 1.4$ Hz), 134.4, 135.3. MS (ESI, m/z): 474.2($\text{M} + \text{NH}_4^+$), 473.2($\text{M} + \text{H}^+ - \text{H}_2\text{O}$). HRMS (MALDI): m/z calcd for $\text{C}_{22}\text{H}_{27}\text{FO}_5\text{S}_2\text{Na}$ ($\text{M} + \text{Na}^+$) 477.1182, found 477.1176.

IR(KBr): 3545, 3103, 3068, 2918, 1477, 1448, 1350, 1313, 1169.

2-Bis(benzenesulfonyl)chloromethyl cyclohexanol (20g):

84% yield □ white crystals, m.p. 143–145°C.

^1H NMR (CDCl_3): δ 0.80–2.40 (m, 8H), 3.38 (s, 1H), 4.32 (m, 1H), 7.46 (m, 4H), 7.68 (m, 2H), 7.86 (d, $J = 8.2$ Hz, 4H). ^{19}F NMR (CDCl_3): δ -129.7 (d, $J = 22$ Hz, 1F). ^{13}C NMR (CDCl_3): δ 24.5, 25.9(d, $J = 1.3$ Hz), 26.0(d, $J = 8.9$ Hz), 35.4, 51.4(d, $J = 14$ Hz), 70.3 (d, $J = 2.0$ Hz), 118.0 (d, $J = 269$ Hz), 116.4, 119.9, 128.94, 128.98, 129.00, 130.40, 131.11, 131.13, 135.06, 135.26, 135.65, 135.88

MS (EI, m/z): 271($\text{M}^+ - \text{PhSO}_2$), 143, 125, 109, 97. EA calcd. For $\text{C}_{19}\text{H}_{21}\text{FO}_5\text{S}_2$: C, 55.32; H, 5.13; Found C, 56.29; H, 5.13.

IR(KBr): 3595, 3559, 3068, 2955, 2930, 1448, 1329, 1156, 1075 .

References:

1. Middelbos, W. et al.; *Tetrahedron Lett.*, **1971**, 351-352.
2. *Encyclopedia of Reagents for Organic Synthesis*, Vol. 4, pp 2558-2561, Paquette, L. A., et.al Eds; John Wiley & Sons: Chichester, 2002.
3. Evans, D. A.; Faul, M. M.; Bilodeau, M. T. *J. Org. Chem.* **1991**; *56*, 6744-6746.
4. Goeksu, S.; Secen, H.; Suetbeyaz, Y. *Synthesis*, **2002**, *16*, 2373
5. Lemini, C.; Ordonez, M.; Perez-Flores, J.; Cruz-Almanza, R. *Synth. Commun.*, **1995**, *25(18)*, 2695.
6. Corey, E. J. and Chaykovsky, M. *J. Am. Chem. Soc.*, 1965, **86**, 1353-1364.

NMR spectra for all products

(15a) ¹H NMR

(15a) ¹³C NMR

(17) ^1H NMR

(17) ^{19}F NMR

(17) ^{13}C NMR

(20a) ¹³C NMR