Supporting Information for

Efficient synthesis of ferrocifens and other ferrocenyl-substituted ethylenes via a ‘sulfur approach’

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Products obtained in the study - supplementation

S-1. Alkyl ferrocenyl ketones

S-1.1. Ethyl ferrocenyl ketone. Orange solid; yield: 213 mg (88%); m.p. 66.5–68.7 °C (ref.51 67–68 °C). 1H NMR (600 MHz, CDCl3): δ 1.20 (t, 3H, JH,H= 7.2 Hz, CH3), 2.73 (q, 2H, JH,H = 7.2 Hz, CH2), 4.18 (bs, 5H, 5 Fc-CH), 4.48 (t, 2H, JH,H = 1.8 Hz, 2 Fc-CH), 4.78 (t, 2H, JH,H = 1.8 Hz, 2 Fc-CH) ppm. 13C{1H}NMR (150 MHz, CDCl 3): δ 12.0, 17.2 (2 CH3), 26.9 (CH2), 44.3 (CH), 69.3, 72.0, 72.1 (4 CH-Fc), 69.5 (5 CH-Fc), 78.9 (C-Fc), 208.3 (C=O) ppm.

S-1.2. Ferrocenyl propyl ketone. Red solid; yield: 192 mg (75%); m.p. 36.1–38.3 °C (ref.52 36.0–38.0 °C). 1H NMR (600 MHz, CDCl3): δ 1.02 (t, 3H, JH,H= 7.2 Hz, CH3), 1.72–1.79 (m, 2H, CH2), 2.69 (t, 2H, JH,H = 7.2 Hz, CH2), 4.20 (bs, 5H, 5 Fc-CH), 4.49 (t, 2H, JH,H = 1.8 Hz, 2 Fc-CH), 4.79 (t, 2H, JH,H = 1.8 Hz, 2 Fc-CH) ppm. 13C{1H}NMR (150 MHz, CDCl3): δ 4.10 (CH3), 18.0 (CH2), 41.7 (CH2), 69.3, 72.0 (4 CH-Fc), 69.7 (5 CH-Fc), 79.3 (C-Fc), 204.4 (C=O) ppm.

S-1.3. Ferrocenyl (sec-butyl) ketone. Thick orange oil; yield: 221 mg (82%). 1H NMR (600 MHz, CDCl3): δ 1.00 (t, 3H, JH,H= 7.2 Hz, CH3), 1.20 (d, 3H, JH,H = 7.2 Hz, CH3), 1.42–1.52, 1.77–1.87 (2m, CH2), 2.88–2.94 (m, 1H, CH), 4.21 (bs, 5H, 5 Fc-CH), 4.50 (bs, 2H, 2 Fc-CH), 4.78 (bs, 1H, Fc-CH), 4.80 (bs, 1H, Fc-CH) ppm. 13C{1H }NMR (150 MHz, CDCl3): δ 12.0, 17.2 (2 CH3), 26.9 (CH2), 44.3 (CH), 69.3, 72.0, 72.1 (4 CH-Fc), 69.5 (5 CH-Fc), 78.9 (C-Fc), 208.3 (C=O) ppm. IR (KBr): ν 3098w, 2965m, 2933m, 2873w, 1666vs (C=O), 1451m, 1378m, 1268m, 1239m, 1106m, 1062m, 1030m, 1002m, 888m, 827m cm⁻¹. Anal. calcd. for C15H18FeO (270.15): C 66.69, H 6.73; found: C 66.48, H 6.72.
S-2. Alkyl ferrocenyl thioketones 7b–d

S-2.1. Ethyl ferrocenyl thioketone (7b). Violet solid; yield: 206 mg (80%); m.p. 37.0–39.0 °C. 1H NMR (600 MHz, CDCl3): δ 1.39 (t, 3H, J_H,H= 6.6 Hz, CH₃), 3.09 (q, 2H, CH₂), 4.18 (bs, 5H, 5 Fc-CH), 4.73 (bs, 2H, 2 Fc-CH), 5.05 (bs, 2H, 2 Fc-CH) ppm. 13C{1H} NMR (150 MHz, CDCl₃): δ 14.6 (CH₃), 42.1 (CH₂), 69.9, 74.0 (4 CH-Fc), 71.2 (5 CH-Fc), 89.0 (C-Fc), 247.9 (C=S) ppm. IR (KBr): ν 3110w, 2969w, 1440s, 1373m, 1262s, 1223m, 1154m, 1043m, 967m, 836m, 819s, 776m, 513s, 480m cm⁻¹. Anal. calcd. for C₁₃H₁₄FeS (258.16): C 60.48, H 5.47, S 12.42; found: C 60.58, H 5.50, S 12.49.

S-2.2. Ferrocenyl propyl thioketone (7c). Violet solid; yield: 199 mg (73%); m.p. 30.0–32.0 °C. 1H NMR (600 MHz, CDCl₃): δ 1.04 (t, 3H, J_H,H= 7.2 Hz, CH₃), 1.84–1.92 (m, 2H, CH₂), 3.03–3.09 (m, 2H, CH₂), 4.19 (bs, 5H, 5 Fc-CH), 4.73 (t, 2H, J_H,H = 1.8 Hz, 2 Fc-CH), 5.03 (t, 2H, J_H,H = 1.8 Hz, 2 Fc-CH) ppm. 13C{1H} NMR (150 MHz, CDCl₃): δ 13.9 (CH₃), 24.0 (CH₂), 51.5 (CH₂), 70.0, 74.2 (4 CH-Fc), 71.3 (5 CH-Fc), 89.3 (C-Fc), 246.7 (C=S) ppm. IR (KBr): ν 3091w, 2960s, 2930m, 2871m, 1669s, 1443vs, 1380s, 1285m, 1107m, 1052m, 1002m, 822vs, 500m cm⁻¹. Anal. calcd. for C₁₄H₁₆FeS (272.19): C 61.78, H 5.92, S 11.78; found: C 61.81, H 5.90, S 11.73.

S-2.3. Ferrocenyl (sec-butyl) thioketone (7d). Violet solid; yield: 215 mg (75%); m.p. 35.0–37.0 °C. 1H NMR (600 MHz, CDCl₃): δ 0.96 (t, 3H, J_H,H= 7.2 Hz, CH₃), 1.34 (d, 3H, J_H,H = 6.6 Hz, CH₃), 1.57–1.67, 1.83–1.95 (2m, 2H, CH₂), 3.34–3.45 (m, 1H, CH), 4.19 (bs, 5H, 5 Fc-CH), 4.68–4.78 (m, 2H, 2 Fc-CH), 5.01 (bs, 1H, Fc-CH), 5.08 (bs, 1H, Fc-CH) ppm. 13C{1H} NMR (150 MHz, CDCl₃): δ 12.2 (CH₃), 22.1 (CH₃), 31.5 (CH₂), 51.6 (CH), 69.7, 70.0, 73.9, 74.2 (4 CH-Fc), 71.0 (5 CH-Fc), 90.0 (C-Fc), 253.7 (C=S) ppm. IR (KBr): ν 3104m, 2961s, 2923m, 2871s, 1669s, 1443vs, 1380s, 1285m, 1107m, 1052m, 1002m, 822vs, 500m cm⁻¹. Anal. calcd. for C₁₅H₁₈FeS (286.21): C 62.95, H 6.34, S 11.20; found: C 62.89, H 6.34, S 11.19.

S-3. Ferrocenyl substituted thiiranes 8d,f

S-3.1. 3-Ferrocenyl-3-methyl-2,2-diphenylthiirane (8d). Yellow solid; yield: 271 mg (66%); m.p. 156.1–158.3 °C. 1H NMR (600 MHz, CDCl₃): δ 1.87 (s, CH₃), 3.57 (bs, 1H, Fc-CH), 3.87 (bs, 1H, Fc-CH), 4.14 (bs, 1H, Fc-CH), 4.19 (bs, 5H, 5 Fc-CH), 4.42 (bs, 1H, Fc-CH), 7.02–7.06 (m, 3H, 3 CH arom.), 7.13–7.20 (m, 3H, 3 CH arom.), 7.24–7.28 (m, 2H, 2 CH arom.), 7.48–7.51 (m, 2H, 2 CH arom.) ppm. 13C{1H} NMR (150 MHz, CDCl₃): δ 12.2 (CH₃), 22.1 (CH₃), 31.5 (CH₂), 51.6 (CH), 69.7, 70.0, 73.9, 74.2 (4 CH-Fc), 71.0 (5 CH-Fc), 90.0 (C-Fc), 253.7 (C=S) ppm. IR (KBr): ν 3104m, 2961s, 2923m, 1451m, 1439vs, 1378m, 1283m, 1252m, 1223m, 1163m, 1036m, 827m, 685m, 511m cm⁻¹. Anal. calcd. for C₁₅H₁₈FeS (286.21): C 62.95, H 6.34, S 11.20; found: C 62.89, H 6.34, S 11.19.
S-3.2. 3'-Ferrocenyl-3'-methyl-10,11-dihydro-5H-spiro[dibenzo[a,d][7]annulene-5,2'-thirane] (8f). Yellow solid; yield: 306 mg (66%); m.p. 154.0–156.0 °C. 1H NMR (600 MHz, CDCl3): δ 1.84 (bs, 3H, CH3), 2.45–2.55, 2.88–2.98, 3.09–3.19, 3.35–3.43 (4m, 4H, 2 CH2), 3.60 (bs, 1H, Fe-C), 3.82 (bs, 1H, Fe-C), 4.00 (bs, 1H, Fe-C), 4.19 (bs, 5H, 5 Fe-C), 4.39 (bs, 1H, Fe-C), 6.83–6.87 (m, 1H, CHarom.), 7.03–7.20 (m, 5H, 5 CHarom.), 7.59–7.62 (m, 1H, CHarom.), 7.67–7.71 (m, 1H, CHarom.) ppm. 13C{1H} NMR (150 MHz, CDCl3): δ 25.3 (CH3), 30.9 (CH2), 32.5 (CH2), 57.3 (Cα), 67.3, 67.6, 69.2, 69.4 (4 CH-Fc), 69.1 (5 CH-Fc), 71.6 (Cα), 89.9 (C-Fc), 125.6, 125.7, 127.4, 127.5, 130.2, 130.3, 130.5 (8 CHarom.), 137.4, 138.3, 138.5, 141.0 (6 C Fe) ppm. IR (KBr): ν 999, 941, 812, 755, 704, 682, 648, 513, 492 cm−1. Anal. calcd. for C25H22FeS (436.39): C 74.31, H 5.54, S 7.35; found: C 74.42, H 5.67, S 7.36.

S-4. Ferrocenyl substituted ethylenes 9d,f−g,j−k,m

S-4.1. 2-Ferrocenyl-1,1-diphenylprop-1-ene (9d). Orange solid; yield: 367 mg (97%); m.p. 157.5–159.8 °C; desulfurization of thirane. 1H NMR (600 MHz, CDCl3): δ 2.20 (s, CH3), 3.93 (t, 2H, JH,H= 1.8 Hz, 2 Fc-C), 4.11 (t, 2H, JH,H = 1.8 Hz, 2 Fc-C), 4.17 (bs, 5H, 5 Fc-C), 7.05–7.09 (m, 2H, 2 CHarom.), 7.16–7.28 (m, 6H, 6 CHarom.), 7.33–7.37 (m, 2H, 2 CHarom.) ppm. 13C{1H} NMR (150 MHz, CDCl3): δ 21.8 (CH3), 68.0, 69.2 (4 CH-Fc), 69.0 (5 CH-Fc), 87.4 (C-Fc), 126.1, 126.2, 127.9, 128.0, 129.8, 130.3 (10 CHarom.), 130.9, 136.3, 144.4 (C=C, 2 CHarom.) ppm. IR KBr: ν 3072w, 3012w, 2917w, 2857w, 1609m, 1594m, 1489m, 1435m, 1271m, 1103m, 1002m, 913m, 812m, 764m, 694vs, 656m, 514m cm−1. Anal. calcd. for C27H24FeS (436.39): C 79.38, H 5.86; found: C 79.42, H 5.67, S 7.35.

S-4.2. 2-Ferrocenyl-1,1-diphenylpent-1-ene (9f). Yellow solid; yield: 306 mg (66%); m.p. 154.0–156.0 °C; spontaneous desulfurization of thirane. 1H NMR (600 MHz, CDCl3): δ 0.83 (t, 3H, JH,H= 7.2 Hz, CH3), 1.46–1.56 (m, 2H, CH2), 2.55–2.59 (m, 2H, CH2), 3.89 (t, 2H, JH,H = 1.8 Hz, 2 Fc-C), 4.08 (t, 2H, JH,H = 1.8 Hz, 2 Fc-C), 4.13 (bs, 5H, 5 Fc-C), 7.07–7.11 (m, 2H, 2 CHarom.), 7.15–7.19 (m, 1H, CHarom.), 7.21–7.24 (m, 5H, 5 CHarom.), 7.31–7.35 (m, 2H, 2 CHarom.) ppm. 13C{1H} NMR (150 MHz, CDCl3): δ 14.4 (CH3), 24.0 (CH2), 37.0 (CH2), 68.1, 69.4 (4 CH-Fc), 69.2 (5 CH-Fc), 87.0 (C-Fc), 126.1, 126.2, 128.1, 128.2, 129.4, 129.9 (10 CHarom.), 135.9, 138.5, 144.7, 144.8 (C=C, 2 CHarom.) ppm. IR KBr: ν 3091m, 3015w, 2925s, 2876m, 2866m, 1609m, 1591m, 1489m, 1464m, 1435m, 1454m, 1103m, 1052m, 1040m, 1002m, 1017m, 919m, 812m, 755m, 704vs, 694s, 520m, 495m cm−1. Anal. calcd. for C27H26Fe (406.34): C 79.81, H 6.45; found: C 79.82, H 6.51.

S-4.3. 2-Ferrocenyl-3-methyl-1,1-diphenylpent-1-ene (9g). Orange solid; yield: 326 mg (74%); m.p. 137.0–139.7 °C; spontaneous desulfurization. 1H NMR (600 MHz, CDCl3): δ 0.90 (t, 3H, JH,H= 7.2 Hz, CH3), 1.33 (d, 2H, JH,H = 7.2 Hz, CH2), 1.40–1.47, 1.72–1.79 (2m, 2H, CH2), 2.77–2.84 (m, 1H, CH), 3.79 (bs, 1H, Fe-C), 3.91 (bs, 1H, Fe-C), 4.06 (bs, 2H, 2 Fe-C), 4.12 (bs, 5H, 5 Fe-C), 7.04–7.07 (m, 2H, 2 CHarom.), 7.10–7.15 (m, 1H, CHarom.), 7.17–7.22 (m, 5H, 5 CHarom.), 7.28–7.31 (m, 2H, 2 CHarom.) ppm. 13C{1H} NMR (150 MHz, CDCl3): δ 13.2 (CH3), 21.2 (CH3), 29.6 (CH2), 41.7 (CH), 67.5, 67.6, 70.0, 70.1 (4 CH-Fc),
69.1 (5 CH-Fc), 86.6 (C-Fc), 125.9, 126.1, 127.9, 128.0, 129.2, 129.5 (10 CHarom.), 139.5, 140.1, 145.0, 145.5 (C=C, 2 C arom.) ppm. Anal. calcd. for C_{28}H_{28}Fe (420.37): C 80.0, H 6.71; found: C 80.04, H 6.67.

S-4.4. 9-(1-Ferrocenylbutylidene)-9H-fluorene (9j). Orange solid; yield: 384 mg (95%); m.p. >207 °C (decomposition); spontaneous desulfurization. \(^1\)H NMR (600 MHz, CDCl\(_3\)): \(\delta\) 1.16 (t, 3H, \(J\) \(H,H= 7.2\) Hz, CH\(_3\)), 1.83–1.92 (m, 2H, CH\(_2\)), 3.33–3.40 (m, 2H, CH\(_2\)), 4.24 (bs, 5H, 5 Fc-CH), 4.45 (t, 2H, \(J\) \(H,H= 1.8\) Hz, 2 Fc-CH), 4.51 (t, 2H, \(J\) \(H,H= 1.8\) Hz, 2 Fc-CH), 6.94–7.00 (m, 1H, CHarom.), 7.17–7.21 (m, 2H, 2 CHarom.), 7.34–7.38 (m, 2H, 2 CHarom.), 7.66–7.71 (m, 1H, CHarom.), 7.77–7.80 (m, 1H, CHarom.), 7.84–7.88 (m, 1H, CHarom.) ppm. \(^{13}\)C\{\(^1\)H\} NMR (150 MHz, CDCl\(_3\)): \(\delta\) 14.7 (CH\(_3\)), 23.8 (CH\(_2\)), 41.3 (CH\(_2\)), 68.7, 71.0 (4 CH-Fc), 69.5 (5 CH-Fc), 91.8 (C-Fc), 118.8, 119.4, 124.6, 125.5, 125.7, 126.3, 126.6, 126.8 (8 CH arom.), 134.0, 138.8, 139.0, 139.4, 146.0 (C=C, 4 C arom.) ppm. IR (KBr): \(\nu\) 3104 \(w\), 3050 \(w\), 2949 \(m\), 2923 \(m\), 2863 \(m\), 1609 \(m\), 1591 \(m\), 1461 \(m\), 1445 \(s\), 1429 \(m\), 1106 \(m\), 1021 \(m\), 995 \(m\), 815 \(m\), 786 \(m\), 729 \(vs\), 476 \(s\) cm\(^{-1}\). Anal. calcd. for C\(_{27}\)H\(_{24}\)Fe (404.32): C 80.21, H 5.98; found: C 80.34, H 6.03.

S-4.5. 9-(1-Ferrocenyl-2-methylbutylidene)-9H-fluorene (9k). Orange solid; yield: 343 mg (82%); m.p. 177.0–179.0 °C; spontaneous desulfurization. \(^1\)H NMR (600 MHz, CDCl\(_3\)): \(\delta\) 1.10 (t, 3H, \(J\) \(H,H= 7.2\) Hz, CH\(_3\)), 1.75 (d, 2H, \(J\) \(H,H= 7.2\) Hz, CH\(_2\)), 2.12–2.22, 2.40–2.49 (2m, 2H, CH\(_2\)), 3.82–3.91 (m, 1H, CH), 4.18 (bs, 1H, Fc-CH), 4.24 (bs, 1H, Fc-CH), 4.29 (bs, 5H, 5 Fc-CH), 4.51 (bs, 1H, Fc-CH), 4.55 (bs, 1H, Fc-CH), 5.86–5.93 (m, 1H, CHarom.), 6.85–6.90 (m, 1H, CH arom.), 7.12–7.16 (m, 1H, CH arom.), 7.31–7.37 (m, 2H, 2 CH arom.), 7.61–7.65 (m, 1H, CHarom.), 7.71–7.75 (m, 1H, CHarom.), 7.92–7.98 (m, 1H, CHarom.) ppm. \(^{13}\)C\{\(^1\)H\} NMR (150 MHz, CDCl\(_3\)): \(\delta\) 13.1 (CH\(_3\)), 17.2 (CH\(_3\)), 26.0 (CH\(_2\)), 40.9 (CH), 68.1, 68.2, 72.1, 72.8 (4 CH-Fc), 69.7 (5 CH-Fc), 89.5 (C-Fc), 118.5, 119.3, 125.6, 126.0, 126.3, 126.5, 126.7, 126.8 (8 CH arom.), 137.8, 138.1, 139.0, 139.4, 140.4, 148.6 (C=C, 4 C arom.) ppm. IR (KBr): \(\nu\) 3104 \(w\), 3085 \(w\), 2955 \(w\), 1572 \(m\), 1442 \(s\), 1105 \(m\), 1021 \(m\), 995 \(m\), 834 \(s\), 780 \(m\), 729 \(vs\), 489 \(m\) cm\(^{-1}\). Anal. calcd. for C\(_{28}\)H\(_{26}\)Fe (418.35): C 80.39, H 6.26; found: C 80.36, H 6.33.

S-4.6. 5-(1-Ferrocenylpropylidene)-10,11-dihydro-5H-dibenzo[a,d][7]annulene (9m). Orange solid; yield: 410 mg (98%); m.p. 177.0–179.0 °C; spontaneous desulfurization. \(^1\)H NMR (600 MHz, CDCl\(_3\)): \(\delta\) 1.33 (bs, 3H, CH\(_3\)), 1.45–1.52, 2.28–2.36 (2m, 2H, CH\(_2\)), 2.38–2.48, 2.82–2.93, 2.97–3.09 (4m, 4H, 2 CH\(_2\)), 3.45 (bs, 1H, Fc-CH), 3.79 (bs, 1H, Fc-CH), 4.07 (bs, 1H, Fc-CH), 4.18 (bs, 5H, 5 Fc-CH), 4.46 (bs, 1H, Fc-CH), 6.83–6.90 (m, 1H, CHarom.), 6.95–7.00 (m, 1H, CHarom.), 7.04–7.15 (m, 4H, 4 CHarom.), 7.54–7.65 (m, 2H, 2 CHarom.) ppm. \(^{13}\)C\{\(^1\)H\} NMR (150 MHz, CDCl\(_3\)): \(\delta\) 16.6 (CH\(_3\)), 27.1 (CH\(_2\)), 31.8, 32.7 (2 CH\(_2\)), 68.0, 68.1, 69.1, 69.5 (4 CH-Fc), 69.0 (5 CH-Fc), 85.8 (C-Fc), 126.7, 126.8, 128.7, 129.4, 129.9 (8 CHarom.), 135.7, 136.5, 136.6, 137.4, 142.4, 143.8 (C=C, 4 C arom.) ppm. IR (KBr): \(\nu\) 2990 \(w\), 2961 \(w\), 2936 \(w\), 2895 \(w\), 1480 \(m\), 1458 \(m\), 1293 \(m\), 1287 \(m\), 1201 \(m\), 1103 \(m\), 1030 \(m\), 986 \(m\), 935 \(m\), 817 \(s\), 772 \(s\), 749 \(vs\), 647 \(m\), 512 \(m\), 493 \(s\), 481 \(s\) cm\(^{-1}\). Anal. calcd. for C\(_{28}\)H\(_{26}\)Fe (418.35): C 80.39, H 6.26; found: C 80.27, H 6.40.
References


Collection of the $^1$H and $^{13}$C NMR spectra

1. The $^1$H- and $^{13}$C-NMR for ferrocifens 1a–c.

![Figure S1. The $^1$H NMR spectrum of 1a.](image-url)
Figure S2. The $^{13}$C NMR spectrum of 1a.

Figure S3. The $^1$H NMR spectrum of 1b.
Figure S4. The $^{13}$C NMR spectrum of $1b$.

Figure S5. The $^1$H NMR spectrum of $1c$. 
Figure S6. The $^{13}$C NMR spectrum of 1c

2. The $^1$H- and $^{13}$C-NMR for the ferrocenyl ketones (not numbered in the manuscript).
Figure S9. The $^1$H NMR spectrum of ferrocenyl methyl ketone.

Figure S10. The $^{13}$C NMR spectrum of ferrocenyl methyl ketone.
Figure S11. The $^1$H NMR spectrum of ferrocenyl ethyl ketone.

Figure S12. The $^{13}$C NMR spectrum of ferrocenyl ethyl ketone.
**Figure S13.** The $^1$H NMR spectrum of ferrocenyl $n$-propyl ketone.

**Figure S14.** The $^{13}$C NMR spectrum of ferrocenyl $n$-propyl ketone.
Figure S15. The $^1$H NMR spectrum of ferrocenyl sec-butyl ketone.

Figure S16. The $^{13}$C NMR spectrum of ferrocenyl sec-butyl ketone.

3. The $^1$H- and $^{13}$C-NMR for the described ferrocenyl thioketones 7a–d.
**Figure S17.** The $^1$H NMR spectrum of ferrocenyl methyl thioketone (7a).

**Figure S18.** The $^{13}$C NMR spectrum of ferrocenyl methyl thioketone (7a).
Figure S19. The $^1$H NMR spectrum of ferrocenyl ethyl thioketone (7b).

Figure S20. The $^{13}$C NMR spectrum of ferrocenyl ethyl thioketone (7b).
Figure S21. The $^1$H NMR spectrum of ferrocenyl $n$-propyl thioketone (7c).

Figure S22. The $^{13}$C NMR spectrum of ferrocenyl $n$-propyl thioketone (7c).
Figure S23. The $^1$H NMR spectrum of ferrocenyl sec-butyl thioketone (7d).

Figure S24. The $^{13}$C NMR spectrum of ferrocenyl sec-butyl thioketone (7d)

4. The $^1$H- and $^{13}$C-NMR spectra for thiirane derivatives8a–g.
Figure S25. The $^1$H NMR spectrum of 8a.

Figure S26. The $^{13}$C NMR spectrum of 8a.

Figure S27. The $^1$H NMR spectrum of 8b.
Figure S28. The $^{13}$C NMR spectrum of 8b.

Figure S29. The $^1$H NMR spectrum of 8c.
Figure S30. The $^{13}$C NMR spectrum of 8c.

Figure S33. The $^1$H NMR spectrum of 8d.
Figure S34. The $^{13}$C NMR spectrum of 8d.

Figure S35. The $^1$H NMR spectrum of 8e.
Figure S36. The $^{13}$C NMR spectrum of 8e.

Figure S37. The $^1$H NMR spectrum of 8f.
Figure S38. The $^{13}$C NMR spectrum of 8f.

Figure S35. The $^1$H NMR spectrum of 8g.
**Figure S36.** The $^{13}$C NMR spectrum of compound 8g.

5. The $^1$H- and $^{13}$C-NMR spectra of ethylene derivatives 9a-m.
Figure S37. The $^1$H NMR spectrum of 9a.

Figure S38. The $^{13}$C NMR spectrum of 9a.
Figure S39. The $^1$H NMR spectrum of $9b$.

Figure S40. The $^{13}$C NMR spectrum of $9b$. 
Figure S41. The $^1$H NMR spectrum of 9c.

Figure S42. The $^{13}$C NMR spectrum of 9c.
Figure S43. The $^1$H NMR spectrum of 9d.

Figure S44. The $^{13}$C NMR spectrum of 9d.

Figure S45. The $^1$H NMR spectrum of 9e.
Figure S46. The $^{13}$C NMR spectrum of 9e.

Figure S47. The $^1$H NMR spectrum of 9f.
Figure S48. The $^{13}$C NMR spectrum of 9f.

Figure S49. The $^1$H NMR spectrum of 9g.
Figure S50. The $^{13}$C NMR spectrum of $9g$.

Figure S51. The $^1$H NMR spectrum of $9h$. 
Figure S52. The $^{13}$C NMR spectrum of 9h.

Figure S53. The $^1$H NMR spectrum of 9i.
Figure S54. The $^{13}$C NMR spectrum of 9i.

Figure S55. The $^1$H NMR spectrum of 9j.
Figure S56. The $^{13}$C NMR spectrum of 9j.

Figure S57. The $^1$H NMR spectrum of 9k.
Figure S58. The $^{13}$C NMR spectrum of 9k.

Figure S59. The $^1$H NMR spectrum of 9l.
Figure S60. The $^{13}$C NMR spectrum of 9I.

Figure S61. The $^1$H NMR spectrum of 9m.
Figure S64. The $^{13}$C NMR spectrum of 9m.