An Alternate Method For The Synthesis of Six-membered Carbocycles with Five Stereo Centers: 1,2,3,4,6-Pentasubstituted-4-Hydroxy-Cyclohexanes

Hayreddin Gezezen^{a,*} and Mustafa Ceylan^b

^a Department of Nutrition and Dietetics, Faculty of Health Sciences, Cumhuriyet University, 58140, Sivas, Turkey

^b Department of Chemistry, Faculty of Arts and Sciences, Gaziosmanpasa University, 60250 Tokat, Turkey

e-mail address: gezegenh@cumhuriyet.edu.tr

SUPPLEMENTAL MATERIAL

Spectral Data

((1R,2S,3R,4S,6S)-4-(4-chlorophenyl)-4-hydroxy-2,6-bis(4-methoxyphenyl)cyclohexane-1,3-diyl)bis((4-chlorophenyl)methanone) (3a)

White solid; yield 92%; mp 248-250 °C; IR (KBr, cm⁻¹): 3461, 3066, 3012, 2938, 2836, 1644, 1612, 1582, 1513, 1488, 1400, 1305, 1278, 1253, 1180, 1093, 1012, 827, 536. ¹H NMR (400 MHz, DMSO-*d*₆) δ 7.62 (d, *J* = 8.6 Hz, 2H), 7.44 – 7.36 (m, 4H), 7.34 – 7.19 (m, 8H), 7.17 (d, *J* = 8.6 Hz, 2H), 6.68 (d, *J* = 8.7 Hz, 2H), 6.44 (d, *J* = 9.1 Hz, 2H), 5.29 (s, 1H), 4.91 (d, *J* = 11.5 Hz, 1H), 4.64 (t, *J* = 11.1 Hz, 1H), 3.90 (t, *J* = 11.3 Hz, 1H), 3.65 (td, *J* = 11.8, 3.6 Hz, 1H), 3.56 (s, 3H), 3.40 (s, 3H), 2.82 (t, *J* = 13.0 Hz, 1H), 1.80 (dd, *J* = 13.5, 3.6 Hz, 1H). ¹³C NMR (100 MHz, DMSO-*d*₆) δ 203.2, 202.4, 158.1, 157.9, 146.1, 137.8, 137.6, 137.1, 137.1, 135.1, 132.5, 131.6, 129.9 (2C), 129.6 (2C), 129.2 (2C), 128.3 (4C), 128.3 (2C), 127.9 (2C), 127.6 (2C), 114.0 (2C), 113.5 (2C), 75.1, 56.0, 55.2, 55.1, 54.8, 46.5, 46.4, 42.8. Elemental analysis (%), Calcd for C₄₀H₃₃Cl₃O₅: C, 68.63; H, 4.75. Found: C, 68.52; H, 4.67.

Figure S1. ¹H NMR spectrum (400 MHz, DMSO-*d*₆) of 3a Figure S2. ¹³C NMR spectrum (100 MHz, DMSO-*d*₆) of 3a

Figure S3. APT NMR spectrum (100 MHz, DMSO- d_6) of **3a**

Figure S4. COSY spectrum (400 MHz, DMSO- d_6) of **3a**

Figure S5. HETCOR spectrum (DMSO- d_6) of 3a

Figure S6. HMBC spectrum (DMSO- d_6) of 3a

Figure S7. NOESY spectrum (300 MHz, DMSO- d_6) of **3a**

((1R,2S,3R,4S,6S)-4-(4-chlorophenyl)-4-hydroxy-2,6-di-p-tolylcyclohexane-1,3-diyl)bis((4-chlorophenyl)methanone) (3b**)**

White solid; yield 90%; mp 272-274 °C; IR (KBr, cm^{-1}): 3446, 3019, 2946, 2917, 1666, 1644, 1589, 1567, 1513, 1488, 1400, 1251, 1218, 1093, 1012, 950, 809, 551, 528. ^1H NMR (400 MHz, DMSO- d_6) δ 7.61 (d, J = 8.5 Hz, 2H), 7.39 (dd, J = 8.8, 7.2 Hz, 4H), 7.29 – 7.18 (m, 8H), 7.15 (d, J = 8.5 Hz, 2H), 6.91 (d, J = 7.7 Hz, 2H), 6.68 (d, J = 8.0 Hz, 2H), 5.30 (s, 1H), 4.93 (d, J = 11.5 Hz, 1H), 4.67 (t, J = 11.1 Hz, 1H), 3.92 (t, J = 11.3 Hz, 1H), 3.66 (td, J = 11.8, 3.5 Hz, 1H), 2.84 (t, J = 13.0 Hz, 1H), 2.07 (s, 3H), 1.88 (s, 3H), 1.80 (dd, J = 13.4, 3.6 Hz, 1H). ^{13}C NMR (100 MHz, DMSO- d_6) δ 203.0, 201.9, 146.0, 140.2, 137.7, 137.7, 137.6, 137.2, 137.0, 135.7, 135.6, 131.6, 129.9 (2C), 129.6 (2C), 129.1 (2C), 128.6 (2C), 128.3 (4C), 128.2 (2C), 128.1 (2C), 127.9 (2C), 127.6 (2C), 75.1, 55.9, 54.5, 46.8, 46.3, 43.2, 20.9, 20.7. Elemental analysis (%), Calcd for $\text{C}_{40}\text{H}_{33}\text{Cl}_3\text{O}_3$: C, 71.92; H, 4.98. Found: C, 71.85; H, 4.91.

Figure S8. ¹H NMR spectrum (400 MHz, DMSO-*d*₆) of **3b**

Figure S9. ¹³C NMR spectrum (100 MHz, DMSO-*d*₆) of **3b**

((1R,2S,3R,4S,6S)-2,6-bis(4-bromophenyl)-4-(4-chlorophenyl)-4-hydroxycyclohexane-1,3-diyl)bis((4-chlorophenyl)methanone) (3c)

White solid; yield 89%; mp 262-264 °C; IR (KBr, cm^{-1}): 3446, 3064, 3021, 2946, 2911, 1670, 1660, 1635, 1589, 1567, 1488, 1400, 1251, 1216, 1093, 1012, 975, 838, 817, 536. ^1H NMR (400 MHz, DMSO) δ 7.57 (d, $J = 8.6$ Hz, 2H), 7.43 – 7.23 (m, 14H), 7.16 (d, $J = 8.7$ Hz, 2H), 7.11 (d, $J = 8.4$ Hz, 2H), 5.41 (s, 1H), 4.90 (d, $J = 11.5$ Hz, 1H), 4.69 (t, $J = 11.1$ Hz, 1H), 3.93 (dd, $J = 23.8, 12.4$ Hz, 1H), 3.75 – 3.59 (m, 1H), 2.87 (t, $J = 13.1$ Hz, 1H), 1.83 (dd, $J = 13.3, 3.3$ Hz, 1H). ^{13}C NMR (100 MHz, DMSO) δ 202.6, 201.0, 145.7, 142.4, 140.3, 138.1, 137.8, 137.2 (2C), 136.7, 131.7 (2C), 131.6 (2C), 131.1 (2C), 130.4 (2C), 129.7 (2C), 129.6 (2C), 128.6 (2C), 128.3 (2C), 128.0 (2C), 127.6 (2C), 119.9 (2C), 79.6, 74.8, 55.9, 53.9, 46.4, 43.0. Elemental analysis (%), Calcd for $\text{C}_{38}\text{H}_{27}\text{Br}_2\text{Cl}_3\text{O}_3$: C, 57.21; H, 3.41. Found: C, 57.16; H, 3.38.

Figure S10. ^1H NMR spectrum (400 MHz, DMSO- d_6) of 3c

Figure S11. ^{13}C NMR spectrum (100 MHz, $\text{DMSO}-d_6$) of **3c**

((1R,2S,3R,4S,6S)-4-hydroxy-2,4,6-tris(4-methoxyphenyl)cyclohexane-1,3-diyl)bis((4-methoxyphenyl)methanone) (3d)

White solid; yield 86%; mp 247-259 °C; IR (KBr, cm^{-1}): 3399, 3000, 2952, 2935, 2910, 1656, 1635, 1598, 1571, 1511, 1255, 1228, 1176, 1031, 829, 545. ^1H NMR (400 MHz, $\text{DMSO}-d_6$) δ 7.67 – 7.44 (m, 7H), 7.27 (d, J = 8.2 Hz, 2H), 6.83 – 6.60 (m, 9H), 6.39 (d, J = 8.3 Hz, 2H), 5.27 (s, 1H), 4.98 (d, J = 11.5 Hz, 1H), 4.69 (t, J = 11.0 Hz, 1H), 3.89 (t, J = 11.1 Hz, 1H), 3.75 – 3.68 (m, 1H), 3.64 (s, 3H), 3.63 (s, 3H), 3.56 (s, 3H), 3.54 (s, 3H), 3.35 (s, 3H), 2.73 (t, J = 13.0 Hz, 1H), 1.78 (d, J = 12.2 Hz, 1H). ^{13}C NMR (100 MHz, $\text{DMSO}-d_6$) δ 204.3, 202.1, 163.2, 162.6, 158.0, 157.9, 157.7, 139.5, 135.6, 132.4 (2C), 131.5, 131.0 (4C), 130.4 (2C), 129.2 (2C), 126.5 (2C), 113.8 (2C), 113.3 (4C), 113.3 (4C), 79.6, 75.4, 55.7, 55.6, 55.2, 55.1, 54.9, 54.4, 47.4, 47.2, 43.1. Elemental analysis (%), Calcd for $\text{C}_{43}\text{H}_{42}\text{O}_8$: C, 75.20; H, 6.16. Found: C, 75.17; H, 6.11.

Figure S12. ^1H NMR spectrum (400 MHz, $\text{DMSO-}d_6$) of **3d**

Figure S13. ^{13}C NMR spectrum (100 MHz, $\text{DMSO-}d_6$) of **3d**

((1R,2S,3R,4S,6S)-4-hydroxy-4-(4-methoxyphenyl)-2,6-di-p-tolylcyclohexane-1,3-diyl)bis((4-methoxyphenyl)methanone) (3e)

White solid; yield 87%; mp 253-255 °C; IR (KBr, cm^{-1}): 3426, 3008, 3933, 2838, 1660, 1635, 1600, 1573, 1509, 1344, 1309, 1253, 1168, 1031, 838, 813, 534. ^1H NMR (400 MHz, $\text{DMSO}-d_6$) δ 7.59 (d, $J = 8.5$ Hz, 2H), 7.54 (d, $J = 8.5$ Hz, 2H), 7.50 (d, $J = 8.5$ Hz, 2H), 7.25 (d, $J = 7.8$ Hz, 2H), 6.90 (d, $J = 7.7$ Hz, 2H), 6.77 – 6.58 (m, 10H), 5.21 (s, 1H), 5.03 (d, $J = 11.5$ Hz, 1H), 4.75 (t, $J = 10.9$ Hz, 1H), 3.88 (t, $J = 11.2$ Hz, 1H), 3.73 – 3.67 (m, 1H), 3.63 (s, 3H), 3.61 (s, 3H), 3.56 (s, 3H), 2.77 (t, $J = 13.0$ Hz, 1H), 2.06 (s, 3H), 1.83 (s, 3H), 1.74 (dd, $J = 13.5, 3.7$ Hz, 1H). ^{13}C NMR (100 MHz, $\text{DMSO}-d_6$) δ 204.1, 202.0, 163.1, 162.6, 158.0, 140.7, 139.5, 137.5, 135.3, 135.2, 131.5, 131.0, 131.0 (2C), 130.4 (2C), 129.0 (4C), 128.4 (2C), 128.1 (2C), 126.6 (2C), 113.3 (4C), 113.3 (2C), 75.3, 55.7, 55.6, 55.2, 54.4, 53.4, 47.8, 47.1, 43.6, 20.9, 20.7. Elemental analysis (%), Calcd for $\text{C}_{43}\text{H}_{42}\text{O}_6$: C, 78.87; H, 6.47. Found: C, 78.77; H, 6.39.

Figure S14. ^1H NMR spectrum (400 MHz, $\text{DMSO}-d_6$) of **3e**

Figure S15. ^{13}C NMR spectrum (100 MHz, $\text{DMSO}-d_6$) of **3e**

((1R,2S,3R,4S,6S)-2,6-bis(4-chlorophenyl)-4-hydroxy-4-(4-methoxyphenyl)cyclohexane-1,3-diyl)bis((4-methoxyphenyl)methanone) (3f**)**

White solid; yield 90%; mp 230-232 °C; IR (KBr, cm^{-1}): 3461, 3010, 2935, 2836, 1656, 1637, 1600, 1571, 1509, 1313, 1255, 1226, 1168, 1091, 1031, 1012, 823, 549, 534. ^1H NMR (400 MHz, DMSO) δ 7.72 – 7.43 (m, 8H), 7.36 (d, J = 8.4 Hz, 2H), 7.17 (d, J = 8.4 Hz, 2H), 6.90 (d, J = 8.2 Hz, 2H), 6.79 – 6.63 (m, 6H), 5.24 (s, 1H), 4.96 (d, J = 11.5 Hz, 1H), 4.72 (t, J = 11.0 Hz, 1H), 3.89 (t, J = 11.2 Hz, 1H), 3.75 – 3.70 (m, 1H), 3.67 (s, 6H), 3.57 (s, 3H), 2.76 (t, J = 12.9 Hz, 1H), 1.84 – 1.70 (m, 1H). ^{13}C NMR (100 MHz, DMSO) δ 203.3, 201.5, 163.3, 163.0, 158.1, 142.5, 139.6, 139.1, 131.2, 131.2, 131.1, 130.9, 130.8 (2C), 130.4 (2C), 130.1 (2C), 128.5 (2C), 127.8 (2C), 126.5 (2C), 113.5 (2C), 113.5 (4C), 113.4 (2C), 75.1, 55.8, 55.7, 55.2, 54.2, 53.1, 47.4, 46.5, 43.3. Elemental analysis (%), Calcd for $\text{C}_{41}\text{H}_{36}\text{Cl}_2\text{O}_6$: C, 70.79; H, 5.22. Found: C, 70.71; H, 5.14.

Figure S16. ¹H NMR spectrum (400 MHz, DMSO-*d*₆) of **3f** Figure S17. ¹³C NMR spectrum (100 MHz, DMSO-*d*₆) of **3f**

((1R,2S,3R,4S,6S)-2,6-bis(4-bromophenyl)-4-hydroxy-4-(4-methoxyphenyl)cyclohexane-1,3-diyl)bis((4-methoxyphenyl)methanone) (3g)

White solid; yield 91%; mp 251-253 °C; IR (KBr, cm^{-1}): 3459, 3012, 2933, 2838, 1654, 1635, 1598, 1571, 1509, 1486, 1419, 1313, 1255, 1224, 1168, 1031, 1008, 836, 819, 543, 534. ^1H NMR (400 MHz, $\text{DMSO-}d_6$) δ 7.64 – 7.47 (m, 8H), 7.31 (s, 4H), 7.04 (d, $J = 8.0$ Hz, 2H), 6.76 – 6.67 (m, 6H), 5.27 (s, 1H), 4.99 (d, $J = 11.5$ Hz, 1H), 4.74 (t, $J = 11.0$ Hz, 1H), 3.94 (t, $J = 11.2$ Hz, 1H), 3.78 – 3.72 (m, 1H), 3.64 (s, 6H), 3.55 (s, 3H), 2.78 (t, $J = 12.9$ Hz, 1H), 1.82 (dd, $J = 13.5, 3.5$ Hz, 1H). ^{13}C NMR (100 MHz, $\text{DMSO-}d_6$) δ 203.3, 201.5, 163.3, 163.0, 158.2, 142.9, 140.0, 139.1, 131.4 (2C), 131.2, 130.9 (2C), 130.9 (3C), 130.8 (2C), 130.5 (2C), 130.4 (2C), 126.6 (2C), 119.8, 119.7, 113.5 (2C), 113.4 (4C), 75.1, 55.7, 55.71, 55.2, 54.2, 53.1, 47.5, 46.5, 43.4. Elemental analysis (%), Calcd for $\text{C}_{41}\text{H}_{36}\text{Br}_2\text{O}_6$: C, 62.77; H, 4.63. Found: C, 62.68; H, 4.55.

Figure S18. ^1H NMR spectrum (400 MHz, $\text{DMSO-}d_6$) of **3g**

Figure S19. ^{13}C NMR spectrum (100 MHz, $\text{DMSO}-d_6$) of **3g**

((1R,2S,3R,4S,6S)-4-hydroxy-4-(4-methoxyphenyl)-2,6-di(thiophen-2-yl)cyclohexane-1,3-diyl)bis((4-methoxyphenyl)methanone) (3h**)**

White solid; yield 75%; mp 218-220 °C; IR (KBr, cm^{-1}): 3448, 3070, 2935, 2838, 1660, 1639, 1600, 1571, 1509, 1309, 1253, 1172, 1031, 836, 701, 524. ^1H NMR (400 MHz, $\text{DMSO}-d_6$) δ 7.65 – 7.53 (m, 6H), 7.12 (dd, J = 5.0, 1.1 Hz, 1H), 6.91 (d, J = 3.2 Hz, 1H), 6.82 (dd, J = 4.6, 1.6 Hz, 2H), 6.78 – 6.68 (m, 7H), 6.44 (dd, J = 5.1, 3.4 Hz, 1H), 5.25 (s, 1H), 4.99 (d, J = 11.4 Hz, 1H), 4.60 (t, J = 11.0 Hz, 1H), 4.21 (t, J = 11.3 Hz, 1H), 4.06 (dd, J = 11.8, 3.5 Hz, 1H), 3.70 (d, J = 4.1 Hz, 6H), 3.58 (s, 3H), 2.85 – 2.71 (m, 1H), 1.92 (dd, J = 13.3, 3.5 Hz, 1H). ^{13}C NMR (100 MHz, $\text{DMSO}-d_6$) δ 203.1, 201.6, 163.27, 162.9, 158.2, 146.5, 143.0, 138.8, 131.4, 131.1 (2C), 130.9 (2C), 130.5, 126.9, 126.6, 126.6 (4C), 126.4, 125.1, 124.2, 124.0, 113.4 (2C), 113.3 (2C), 75.1, 55.8, 55.7, 55.3, 54.9, 47.7, 42.8, 39.1. Elemental analysis (%), Calcd for $\text{C}_{37}\text{H}_{34}\text{O}_6\text{S}_2$: C, 69.57; H, 5.36; S, 10.04. Found: C, 69.51; H, 5.26; S, 9.96.

Figure S20. ¹H NMR spectrum (400 MHz, DMSO-*d*₆) of **3h** Figure S21. ¹³C NMR spectrum (100 MHz, DMSO-*d*₆) of **3h**

((1R,2S,3R,4S,6S)-4-hydroxy-2,6-bis(4-methoxyphenyl)-4-(p-tolyl)cyclohexane-1,3-diyl)bis(p-tolylmethanone) (3i)

White solid; yield 89%; mp 265-267 °C; IR (KBr, cm^{-1}): 3423, 2996, 2913, 2834, 1664, 1643, 1606, 1511, 1301, 1253, 1180, 1033, 825, 541. ^1H NMR (400 MHz, $\text{DMSO-}d_6$) δ 7.57 – 7.47 (m, 2H), 7.46 – 7.32 (m, 4H), 7.29 – 7.16 (m, 3H), 7.12 – 6.88 (m, 7H), 6.65 (d, J = 8.8 Hz, 2H), 6.36 (d, J = 7.7 Hz, 2H), 5.14 (s, 1H), 4.97 (d, J = 11.5 Hz, 1H), 4.68 (t, J = 11.1 Hz, 1H), 3.82 (t, J = 11.3 Hz, 1H), 3.69 – 3.62 (m, 1H), 3.56 (s, 3H), 3.37 (s, 3H), 2.69 (t, J = 13.0 Hz, 1H), 2.17 (s, 6H), 2.09 (s, 3H), 1.70 (dd, J = 13.5, 3.6 Hz, 1H). ^{13}C NMR (100 MHz, $\text{DMSO-}d_6$) δ 205.3, 203.4, 157.9, 157.7, 144.4, 143.5, 142.8, 135.9, 135.7, 135.5, 135.5, 132.2, 129.2 (2C), 128.7 (2C), 128.6 (2C), 128.6 (4C), 128.2 (4C), 125.3 (2C), 113.8 (2C), 113.2 (2C), 75.5, 55.2, 54.9, 54.6, 54.0, 47.3, 47.16, 43.1, 21.3, 21.3, 20.8. Elemental analysis (%), Calcd for $\text{C}_{43}\text{H}_{42}\text{O}_5$: C, 80.85; H, 6.63. Found: C, 80.79; H, 6.56.

Figure S22. ^1H NMR spectrum (400 MHz, $\text{DMSO-}d_6$) of **3i**

Figure S23. ^{13}C NMR spectrum (100 MHz, $\text{DMSO}-d_6$) of **3i**

((1R,2S,3R,4S,6S)-4-hydroxy-2,4,6-tri-p-tolylcyclohexane-1,3-diyl)bis(p-tolylmethanone)
(3j)

White solid; yield 90%; mp 267-269 °C; IR (KBr, cm^{-1}): 3448, 3023, 2919, 2861, 1664, 1643, 1606, 1571, 1511, 1447, 1407, 1301, 1257, 1180, 1081, 811, 723, 561, 534. ^1H NMR (400 MHz, $\text{DMSO}-d_6$) δ 7.56 (d, $J = 7.9$ Hz, 2H), 7.47 – 7.35 (m, 4H), 7.25 (d, $J = 7.9$ Hz, 2H), 7.08 – 6.77 (m, 10H), 6.60 (d, $J = 8.0$ Hz, 2H), 5.19 (s, 1H), 5.14 – 5.00 (m, 1H), 4.80 (t, $J = 11.0$ Hz, 1H), 3.91 (t, $J = 11.1$ Hz, 1H), 3.72 (td, $J = 11.7, 3.9$ Hz, 1H), 2.78 (t, $J = 12.9$ Hz, 1H), 2.18 – 1.95 (m, 12H), 1.87 – 1.69 (m, 4H). ^{13}C NMR (100 MHz, $\text{DMSO}-d_6$) δ 205.2, 203.2, 144.4, 143.4, 142.7, 140.6, 137.3, 135.9, 135.6, 135.6, 135.4, 135.3, 129.0 (2C), 128.6 (8C), 128.4 (2C), 128.2 (4C), 128.2 (2C), 125.4 (2C), 75.5, 54.6, 53.7, 47.8, 47.1, 43.6, 21.3, 21.2, 20.9, 20.8, 20.7. Elemental analysis (%), Calcd for $\text{C}_{43}\text{H}_{42}\text{O}_3$: C, 85.11; H, 6.98. Found: C, 85.05; H, 6.91.

Figure S24. ¹H NMR spectrum (400 MHz, DMSO-*d*₆) of 3j Figure S25. ¹³C NMR spectrum (100 MHz, DMSO-*d*₆) of 3j

((1R,2S,3R,4S,6S)-2,6-bis(4-chlorophenyl)-4-hydroxy-4-(p-tolyl)cyclohexane-1,3-diyl)bis(p-tolylmethanone) (3k)

White solid; yield 91%; mp 270-272 °C; IR (KBr, cm^{-1}): 3451, 3027, 2917, 2861, 1660, 1637, 1606, 1569, 1492, 1409, 1301, 1255, 1182, 1093, 1014, 821, 545, 534. ^1H NMR (400 MHz, DMSO) δ 7.52 (d, $J = 6.6$ Hz, 2H), 7.46 – 7.29 (m, 7H), 7.16 (d, $J = 6.5$ Hz, 2H), 7.07 – 6.91 (m, 7H), 6.88 (d, $J = 7.4$ Hz, 2H), 5.20 (s, 1H), 5.01 (d, $J = 11.3$ Hz, 1H), 4.77 (t, $J = 10.6$ Hz, 1H), 3.92 (t, $J = 10.8$ Hz, 1H), 3.72 (t, $J = 11.5$ Hz, 1H), 2.77 (t, $J = 13.0$ Hz, 1H), 2.15 (br s, 6H), 2.06 (s, 3H), 1.78 (d, $J = 13.2$ Hz, 1H). ^{13}C NMR (100 MHz, DMSO) δ 204.3, 202.8, 144.0, 143.7, 143.4, 142.4, 139.4, 135.8, 135.6, 135.5, 131.2, 131.2, 130.1 (4C), 128.9 (2C), 128.8 (2C), 128.6 (2C), 128.5 (4C), 128.1 (2C), 127.9 (2C), 125.3 (2C), 75.3, 54.4, 53.3, 47.4, 46.4, 43.3, 21.3, 20.8. Elemental analysis (%), Calcd for $\text{C}_{41}\text{H}_{36}\text{Cl}_2\text{O}_3$: C, 76.04; H, 5.60. Found: C, 75.99; H, 5.54.

Figure S26. ^1H NMR spectrum (400 MHz, $\text{DMSO}-d_6$) of **3k**

Figure S27. ^{13}C NMR spectrum (100 MHz, $\text{DMSO}-d_6$) of **3k**

((1R,2S,3R,4S,6S)-2,6-bis(4-bromophenyl)-4-hydroxy-4-(p-tolyl)cyclohexane-1,3-diyl)bis(p-tolylmethanone) (3l**)**

White solid; yield 94%; mp 275-277 °C; IR (KBr, cm^{-1}): 3451, 3025, 2859, 1658, 1635, 1604, 1569, 1488, 1407, 1332, 1299, 1255, 1182, 1076, 1008, 971, 819, 727, 541, 528. ^1H NMR (400 MHz, DMSO) δ 7.50 (d, $J = 8.1$ Hz, 4H), 7.36 (m, 4H), 7.33 – 7.22 (m, 4H), 7.10 – 6.87 (m, 8H), 5.18 (s, 1H), 4.99 (d, $J = 11.5$ Hz, 1H), 4.76 (t, $J = 11.1$ Hz, 1H), 3.89 (t, $J = 11.3$ Hz, 1H), 3.74 – 3.62 (m, 1H), 2.76 (t, $J = 12.9$ Hz, 1H), 2.18 (s, 3H), 2.17 (s, 3H), 2.07 (s, 3H), 1.81 – 1.70 (m, 1H). ^{13}C NMR (100 MHz, DMSO) δ 204.4, 202.8, 144.0, 143.7, 143.3, 142.8, 139.8, 135.8, 135.6, 135.5, 131.4 (2C), 130.8 (2C), 130.5 (2C), 128.9 (2C), 128.7 (2C), 128.7 (2C), 128.5 (2C), 128.2 (2C), 125.3 (2C), 119.8 (2C), 119.8 (2C), 75.3, 54.4, 53.2, 47.5, 46.4, 43.4, 21.3 (2C), 20.8. Elemental analysis (%), Calcd for $\text{C}_{41}\text{H}_{36}\text{Br}_2\text{O}_3$: C, 66.86; H, 4.93. Found: C, 66.78; H, 4.89.

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Figure S28. ¹H NMR spectrum (400 MHz, DMSO-*d*₆) of 31

Figure S29. ¹³C NMR spectrum (100 MHz, DMSO-*d*₆) of 31

((1R,2S,3R,4S,6S)-4-(4-bromophenyl)-4-hydroxy-2,6-bis(4-methoxyphenyl)cyclohexane-1,3-diyl)bis((4-bromophenyl)methanone) (3m)

White solid; yield 90%; mp 266-268 °C; IR (KBr, cm^{-1}): 3459, 3031, 2935, 2834, 1666, 1644, 1612, 1583, 1511, 1484, 1396, 1255, 1178, 1074, 1031, 1008, 975, 825, 754, 547, 534. ^1H NMR (400 MHz, $\text{DMSO-}d_6$) δ 7.54 (d, $J = 7.7$ Hz, 2H), 7.45 – 7.35 (m, 5H), 7.35 – 7.26 (m, 7H), 7.22 (d, $J = 8.0$ Hz, 2H), 6.68 (dd, $J = 8.7$, 2.4 Hz, 2H), 6.44 (d, $J = 8.2$ Hz, 2H), 5.29 (s, 1H), 4.88 (d, $J = 11.5$ Hz, 1H), 4.63 (t, $J = 11.2$ Hz, 1H), 3.87 (t, $J = 11.4$ Hz, 1H), 3.65 – 3.54 (m, 4H), 3.37 (s, 3H), 2.81 (t, $J = 13.0$ Hz, 1H), 1.78 (dd, $J = 13.2$, 3.7 Hz, 1H). ^{13}C NMR (100 MHz, $\text{DMSO-}d_6$) δ 203.6, 203.0, 158.0, 157.8, 146.3, 137.2, 137.1, 134.9, 132.2, 131.2 (4C), 130.9 (2C), 130.1 (4C), 129.8 (2C), 129.2 (2C), 127.9 (2C), 127.2, 126.9, 120.3, 113.9 (2C), 113.5 (2C), 75.2, 55.8, 55.2, 54.9, 54.8, 46.6, 46.3, 42.8. Elemental analysis (%), Calcd for $\text{C}_{40}\text{H}_{33}\text{Br}_3\text{O}_5$: C, 57.65; H, 3.99. Found: C, 57.60; H, 3.93.

Figure S30. ^1H NMR spectrum (400 MHz, $\text{DMSO-}d_6$) of **3m**

Figure S31. ^{13}C NMR spectrum (100 MHz, $\text{DMSO}-d_6$) of **3m**

((1R,2S,3R,4S,6S)-4-(4-bromophenyl)-4-hydroxy-2,6-di-p-tolylcyclohexane-1,3-diyl)bis((4-bromophenyl)methanone) (3n**)**

White solid; yield 91%; mp 276-278 °C; IR (KBr, cm^{-1}): 3451, 3048, 2946, 2917, 1668, 1643, 1583, 1563, 1513, 1484, 1396, 1251, 1216, 1072, 1008, 971, 950, 844, 809, 728, 536, 518. ^1H NMR (400 MHz, DMSO) δ 7.57 (d, $J = 8.5$ Hz, 2H), 7.31 (m, 10H), 7.21 (d, $J = 7.8$ Hz, 4H), 6.91 (d, $J = 7.8$ Hz, 2H), 6.67 (d, $J = 7.9$ Hz, 2H), 5.27 (s, 1H), 4.95 (t, $J = 17.9$ Hz, 1H), 4.66 (t, $J = 11.1$ Hz, 1H), 3.94 (t, $J = 11.3$ Hz, 1H), 3.78 – 3.60 (m, 1H), 2.84 (t, $J = 13.0$ Hz, 1H), 2.04 (s, 3H), 1.86 (s, 3H), 1.85 – 1.74 (m, 1H). ^{13}C NMR (100 MHz, DMSO) δ 203.2, 202.3, 146.5, 140.2, 137.6, 137.5, 137.3, 135.7, 135.6, 131.2 (6C), 130.9 (2C), 130.0 (2C), 129.8 (2C), 129.1 (2C), 128.7 (2C), 128.1 (2C), 128.0 (2C), 127.0, 126.8, 120.2, 75.1, 55.9, 54.5, 46.8, 46.2, 43.2, 20.9, 20.7. Elemental analysis (%), Calcd for $\text{C}_{40}\text{H}_{33}\text{Br}_3\text{O}_3$: C, 59.95; H, 4.15. Found: C, 59.89; H, 4.10.

Figure S32. ¹H NMR spectrum (400 MHz, DMSO-*d*₆) of **3n**

Figure S33. ¹³C NMR spectrum (100 MHz, DMSO-*d*₆) of **3n**

((1R,2S,3R,4S,6S)-2,4,6-tris(4-bromophenyl)-4-hydroxycyclohexane-1,3-diyl)bis((4-bromophenyl)methanone) (3o)

White solid; yield 88%; mp 263-265 °C; IR (KBr, cm^{-1}): 3450, 3075, 3021, 2948, 2917, 1666, 1641, 1583, 1562, 1486, 1432, 1396, 1319, 1251, 1214, 1178, 1074, 1008, 970, 950, 842, 813, 759, 730, 649, 538, 516. ^1H NMR (400 MHz, $\text{DMSO-}d_6$) δ 7.53 (d, $J = 8.5$ Hz, 2H), 7.45 – 7.36 (m, 6H), 7.34 – 7.26 (m, 10H), 7.10 (d, $J = 8.1$ Hz, 2H), 5.42 (s, 1H), 4.90 (d, $J = 11.5$ Hz, 1H), 4.70 (t, $J = 11.1$ Hz, 1H), 3.97 (t, $J = 11.2$ Hz, 1H), 3.69 (td, $J = 11.7, 3.6$ Hz, 1H), 2.88 (t, $J = 13.0$ Hz, 1H), 1.85 (dd, $J = 13.4, 3.5$ Hz, 1H). ^{13}C NMR (100 MHz, $\text{DMSO-}d_6$) δ 202.8, 201.3, 146.1, 142.4, 140.2, 137.5, 137.0, 131.5 (2C), 131.5 (2C), 131.3 (2C), 131.1 (2C), 130.9 (2C), 130.4 (2C), 129.8 (2C), 129.7 (2C), 128.0 (2C), 127.3, 127.0, 120.4, 120.1 (2C), 120.0 (2C), 74.9, 55.8, 53.8, 46.4, 45.6, 43.0. Elemental analysis (%), Calcd for $\text{C}_{38}\text{H}_{27}\text{Br}_5\text{O}_3$: C, 49.02; H, 2.92. Found: C, 48.94; H, 2.88.

Figure S34. ^1H NMR spectrum (400 MHz, $\text{DMSO-}d_6$) of **3o**

Figure S35. ^{13}C NMR spectrum (100 MHz, $\text{DMSO}-d_6$) of **30**

((1R,2S,3R,4S,6S)-4-hydroxy-2,4,6-tri(thiophen-2-yl)cyclohexane-1,3-diyl)bis(thiophen-2-ylmethanone) (3p)

White solid; yield 68%; mp 284-286 °C; IR (KBr, cm^{-1}): 3365, 3091, 2925, 1644, 1606, 1515, 1436, 1413, 1355, 1305, 1257, 1218, 1170, 1072, 1039, 933, 904, 848, 836, 781, 703, 588, 524. ^1H NMR (400 MHz, $\text{DMSO}-d_6$) δ 7.71 (t, $J = 4.6$ Hz, 2H), 7.61 (s, 1H), 7.48 (s, 1H), 7.16 (dt, $J = 10.2, 5.5$ Hz, 3H), 7.03 – 6.89 (m, 4H), 6.89 – 6.69 (m, 3H), 6.60 – 6.46 (m, 1H), 5.79 (s, 1H), 4.71 (d, $J = 11.4$ Hz, 1H), 4.33 (t, $J = 11.0$ Hz, 1H), 4.21 (t, $J = 11.3$ Hz, 1H), 4.05 – 3.92 (m, 1H), 2.81 (t, $J = 13.0$ Hz, 1H), 2.21 (dd, $J = 13.3, 3.5$ Hz, 1H). ^{13}C NMR (100 MHz, $\text{DMSO}-d_6$) δ 195.4, 194.7, 152.5, 145.8 (2C), 145.6, 142.8, 135.6, 135.4, 134.5, 133.5, 128.4 (2C), 127.3, 127.0, 126.7, 126.6, 125.3, 124.5 (2C), 124.3, 123.5, 74.4, 58.9, 58.6, 48.2, 42.0, 38.4. Elemental analysis (%), Calcd for $\text{C}_{28}\text{H}_{22}\text{O}_3\text{S}_5$: C, 59.34; H, 3.91; S, 28.28. Found: C, 59.30; H, 3.86; S, 28.21.

Figure S36. ^1H NMR spectrum (400 MHz, $\text{DMSO-}d_6$) of **3p** Figure S37. ^{13}C NMR spectrum (100 MHz, $\text{DMSO-}d_6$) of **3p**

((1R,2S,3R,4S,6S)-4-hydroxy-2,6-bis(4-methoxyphenyl)-4-(thiophen-2-yl)cyclohexane-1,3-diyl)bis(thiophen-2-ylmethanone) (3r)

White solid; yield 72%; mp 264-266 °C; IR (KBr, cm^{-1}): 3440, 3099, 3085, 3012, 2954, 2933, 2836, 1633, 1612, 1583, 1513, 1461, 1415, 1355, 1305, 1259, 1180, 1085, 1070, 1031, 933, 906, 858, 829, 802, 750, 727, 707, 549, 528. ^1H NMR (400 MHz, $\text{DMSO-}d_6$) δ 7.67 (d, $J = 4.9$ Hz, 1H), 7.59 (d, $J = 4.6$ Hz, 2H), 7.47 (d, $J = 3.9$ Hz, 1H), 7.29 (d, $J = 8.2$ Hz, 3H), 7.16-7.12 (m, 3H), 6.95 (t, $J = 4.4$ Hz, 1H), 6.89 (t, $J = 4.4$ Hz, 1H), 6.83 – 6.77 (m, 1H), 6.72 (d, $J = 8.2$ Hz, 2H), 6.48 (d, $J = 8.2$ Hz, 2H), 5.71 (s, 1H), 4.70 (d, $J = 11.7$ Hz, 1H), 4.44 (t, $J = 11.1$ Hz, 1H), 3.89 (t, $J = 11.3$ Hz, 1H), 3.70 – 3.61 (m, 1H), 3.58 (s, 3H), 3.42 (s, 3H), 2.75 (t, $J = 13.1$ Hz, 1H), 2.12 – 1.99 (m, 1H). ^{13}C NMR (100 MHz, $\text{DMSO-}d_6$) δ 195.9 (2C), 158.1, 157.8, 153.3, 146.0, 145.9 (2C), 135.6, 135.0, 134.9, 134.2, 133.1, 132.1, 129.2 (2C), 128.4 (2C), 128.2, 127.2, 124.3, 123.2, 113.9 (2C), 113.3 (2C), 74.7, 58.3, 56.5, 55.2, 55.0, 47.9, 46.5, 42.5. Elemental analysis (%), Calcd for $\text{C}_{34}\text{H}_{30}\text{O}_5\text{S}_3$: C, 66.42; H, 4.92; S, 15.65. Found: C, 66.29; H, 4.81; S, 15.52.

Figure S38. ^1H NMR spectrum (400 MHz, $\text{DMSO-}d_6$) of **3r**

Figure S39. ^{13}C NMR spectrum (100 MHz, $\text{DMSO}-d_6$) of **3r**

((1R,2S,3R,4S,6S)-2,6-bis(4-fluorophenyl)-4-hydroxy-4-(thiophen-2-yl)cyclohexane-1,3-diyl)bis(thiophen-2-ylmethanone) (3s)

White solid; yield 84%; mp 255-257 °C; IR (KBr, cm^{-1}): 3440, 3085, 3037, 2944, 2913, 1641, 1606, 1509, 1413, 1357, 1313, 1299, 1259, 1241, 1226, 1159, 1072, 931, 860, 833, 759, 719, 700, 609, 536. ^1H NMR (400 MHz, $\text{DMSO}-d_6$) δ 7.68 (d, $J = 4.9$ Hz, 1H), 7.64 (d, $J = 3.7$ Hz, 1H), 7.56 (s, 1H), 7.48 (s, 1H), 7.44 – 7.36 (m, 2H), 7.21 – 7.11 (m, 3H), 7.06 – 6.88 (m, 5H), 6.84 – 6.70 (m, 3H), 5.78 (s, 1H), 4.71 (d, $J = 11.7$ Hz, 1H), 4.49 (t, $J = 11.0$ Hz, 1H), 3.95 (t, $J = 11.5$ Hz, 1H), 3.72 (t, $J = 11.9$ Hz, 1H), 2.81 (t, $J = 13.0$ Hz, 1H), 2.10 (d, $J = 13.3$ Hz, 1H). ^{13}C NMR (100 MHz, $\text{DMSO}-d_6$) δ 196.0, 195.7, 162.8, 162.6, 160.4, 160.2, 153.5 (2C), 146.3 (2C), 146.2, 139.5, 136.9, 136.2, 135.8, 134.5, 133.8, 130.6 (2C), 130.5, 128.9 (2C), 128.8, 127.7, 124.9, 123.8, 115.9 (2C), 115.7 (2C), 115.4, 115.2, 75.0, 58.7, 56.7, 47.9, 46.9, 43.0, 41.3. Elemental analysis (%), Calcd for $\text{C}_{32}\text{H}_{24}\text{F}_2\text{O}_3\text{S}_3$: C, 65.07; H, 4.10; S, 16.28. Found: C, 65.01; H, 4.07; S, 16.23.

Figure S40. ^1H NMR spectrum (400 MHz, $\text{DMSO-}d_6$) of **3s**

Figure S41. ^{13}C NMR spectrum (100 MHz, $\text{DMSO-}d_6$) of **3s**

((1R,2S,3R,4S,6S)-4-hydroxy-4-phenyl-2,6-di-p-tolylcyclohexane-1,3-diyl)bis(phenylmethanone) (3t)

White solid; yield 86%; mp 269-271 °C (Lit. 88%, 197-198 °C) ^[1]; IR (KBr, cm⁻¹): 3498, 3056, 3023, 2950, 2917, 1666, 1637, 1594, 1577, 1513, 1448, 1348, 1255, 1220, 1189, 1068, 1000, 975, 815, 759, 694, 682, 563, 536. ¹H NMR (400 MHz, DMSO-*d*₆) δ 7.64 (d, *J* = 7.3 Hz, 2H), 7.45 – 7.39 (m, 4H), 7.30 – 7.21 (m, 5H), 7.17 – 7.07 (m, 7H), 6.97 – 6.88 (m, 3H), 6.63 (d, *J* = 8.0 Hz, 2H), 5.15 (s, 1H), 5.02 (d, *J* = 11.5 Hz, 1H), 4.75 (t, *J* = 11.1 Hz, 1H), 3.94 (t, *J* = 11.3 Hz, 1H), 3.72 (td, *J* = 11.9, 3.6 Hz, 1H), 2.83 (t, *J* = 12.8 Hz, 1H), 2.07 (s, 3H), 1.84 (s, 3H), 1.80 (dd, *J* = 13.4, 3.7 Hz, 1H). ¹³C NMR (100 MHz, DMSO-*d*₆) δ 204.7, 204.0, 147.0, 140.4, 138.5, 138.3, 137.5, 135.5, 135.4, 132.8, 132.5, 129.0 (2C), 128.4 (2C), 128.2 (4C), 128.2 (2C), 128.0 (2C), 127.9 (4C), 127.9 (2C), 126.8, 125.5 (2C), 75.4, 55.4, 54.3, 47.4, 46.7, 43.4, 20.9, 20.7. Elemental analysis (%), Calcd for C₄₀H₃₆O₃: C, 85.08; H, 6.43. Found: C, 85.02; H, 6.37.

Figure S42. ¹H NMR spectrum (400 MHz, DMSO-*d*₆) of **3t**

Figure S43. APT NMR spectrum (100 MHz, DMSO- d_6) of **3t**

((1R,2S,3R,4S,6S)-4-hydroxy-2,6-bis(4-methoxyphenyl)-4-phenylcyclohexane-1,3-diyl)bis(phenylmethanone) (3u)

White solid; yield 87%; mp 239-241 °C (Lit. 92%, mp 180-182 °C)^[1]; IR (KBr, cm^{-1}): 3399, 3068, 3006, 2952, 2910, 2836, 1656, 1635, 1598, 1571, 1511, 1461, 1419, 1307, 1255, 1176, 1118, 1081, 1031, 973, 829, 755, 686, 545. ^1H NMR (400 MHz, DMSO- d_6) δ 7.64 (d, J = 7.0 Hz, 2H), 7.42 (d, J = 8.5 Hz, 4H), 7.33 – 7.23 (m, 5H), 7.20 – 7.07 (m, 7H), 6.99 – 6.91 (m, 1H), 6.67 (d, J = 8.7 Hz, 2H), 6.38 (d, J = 9.0 Hz, 2H), 5.15 (s, 1H), 5.00 (d, J = 11.5 Hz, 1H), 4.72 (t, J = 11.1 Hz, 1H), 3.90 (t, J = 11.3 Hz, 1H), 3.68 (td, J = 11.8, 3.4 Hz, 1H), 3.56 (s, 3H), 3.38 (s, 3H), 2.80 (t, J = 13.3 Hz, 1H), 1.77 (dd, J = 13.4, 3.6 Hz, 1H). ^{13}C NMR (100 MHz, DMSO) δ 205.0, 204.2, 158.0, 157.8, 147.1, 138.5, 138.3, 135.4, 132.9, 132.5, 132.4, 129.2 (2C), 128.2 (2C), 128.1 (2C), 128.0 (7C), 127.9 (2C), 126.8, 125.5 (2C), 113.9 (2C), 113.3, 75.5, 55.4, 55.2, 55.0, 54.6, 47.0, 46.8, 43.0. Elemental analysis (%), Calcd for $\text{C}_{40}\text{H}_{36}\text{O}_5$: C, 80.51; H, 6.08. Found: C, 80.45; H, 6.02.

Figure S44. ^1H NMR spectrum (400 MHz, $\text{DMSO}-d_6$) of **3u** Figure S45. APT NMR spectrum (100 MHz, $\text{DMSO}-d_6$) of **3u**

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