Supporting Information

A new halide-free efficient reaction-controlled phase-transfer catalyst based on silicotungstate of 
\[(\text{C}_{18}\text{H}_{37})_2(\text{CH}_3)_2\text{N}]_3[\text{SiO}_4\text{H(WO}_5\text{)}_3] \]
for olefin epoxidation, oxidation of sulfides and alcohols with hydrogen peroxide

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Preparation of catalysts

K₈ [[β₂-SiW₁₁O₃₉]]·14H₂O

Sodium metasilicate (2.2 g, 10 mmol) was dissolved in 20 mL of water (Solution A). Sodium tungstate (36.4 g, 0.11 mol) was dissolved in 60 mL of water in a separate 250 ml beaker containing a magnetic stirring bar. To this solution, 33 mL of 4 M HCl was added in 1mL portions over 10 min, with vigorous stirring (there was local formation of hydrated tungstic acid that slowly disappears). Then, solution A was poured into the tungstate solution, and the pH was adjusted to 5.5 by addition of the 4 M HCl solution (~ 8 mL). This pH was maintained by addition of small amounts of 4 M HCl for 100 min. Solid potassium chloride (18 g) was then added to the solution with gentle stirring. After 15 min, the precipitate was collected by filtering through a sintered glass filter. Purification was achieved by dissolving the product in 170 mL of water. The insoluble material was rapidly removed by filtration on a funnel, and the salt was precipitated again by addition of solid KCl (16 g). The precipitate was separated by filtration, washed with 2M potassium chloride solution (2 portions of 10mL), and air dried. Yield: 12.9 g (40%). IR spectrum (KBr, cm⁻¹): 991, 950, 879, 863, 803, 728, 610, 532, 513, 397, 360, 322, 270.

K₈ [γ-SiW₁₀O₃₆]·12H₂O

The potassium salt of the β₂ isomer of undecatungstosilicate (5 g, 1.67 mmol) was dissolved in 50 mL of water maintained at 298 K. Impurities in the K₈[[β₂-SiW₁₁O₃₉]] salt gave insoluble materials, which have to be removed rapidly by filtration on a funnel. The pH of the solution was quickly adjusted to 9.1 by addition of a 2 M aqueous solution of K₂CO₃. The pH of the solution was kept at this value by addition of the K₂CO₃ solution for exactly 16 min. The potassium salt of
the γ-decatungstosilicate was then precipitated by addition of solid potassium chloride (13.3 g). During the precipitation (10 min), the pH must be maintained at 9.1 by addition of small amounts of the K$_2$CO$_3$ solution. The solid was removed by filtering, washed with 1 M KCl solution, and air dried. Yield: 3.2 g (64%). IR spectrum (KBr, cm$^{-1}$): 990, 946, 907, 865, 817, 742, 654, 554, 525, 479, 393, 361, 323, 279, 250. $^{29}$Si MAS NMR (79.5 MHz): -85.0 ppm.

[(C$_{18}$H$_{37}$)$_2$(CH$_3$)$_2$N]$_2$[W$_3$O$_{18}$]:

A suspension of H$_2$WO$_4$ (2.0 g, 8.0 mmol) in 30% aqueous H$_2$O$_2$ (6.7 ml, 67 mmol) was stirred at 323 K for 60 min until a pale yellow solution was obtained. The solution was cooled to ambient temperature and filtered to remove insoluble materials. To this solution 1.0 g (1.7 mmol) of dioctadecyl dimethyl ammonium chloride (DDAC) dissolved in 20 ml of tert-butanol was added. The mixture was stirred vigorously for 4 h at 318 K. A white floccule was filtered off and then washed with warm water (~318 K, about 60 ml) and diethyl ether (25 ml). After dried in air, a white powder was obtained. Anal. calcd for [DDA]$_2$[W$_3$O$_{18}$]: C, 47.14; H, 8.27; N, 1.45; W, 28.51; Found: C, 46.87; H, 7.95; N, 1.31; W, 26.82. Yield: 1.8 g. IR spectrum (KBr, cm$^{-1}$): 2920, 2851, 2359, 1718, 1643, 1466, 1374, 1079, 977, 880, 816, 719, 681, 627, 558, 446.

[(C$_{18}$H$_{37}$)$_2$(CH$_3$)$_2$N]$_8$[β$_2$-SiW$_{11}$O$_{39}$]:

K$_8$[β$_2$-SiW$_{11}$O$_{39}$]·12H$_2$O was prepared according to ref. [1]. A solution of K$_8$[β$_2$-SiW$_{11}$O$_{39}$]·12H$_2$O (0.65 g, 0.2 mmol) in 20 ml water was stirred vigorously. And to this solution 0.94 g (1.6 mmol) of dioctadecyl dimethyl ammonium chloride dissolved in 18 ml tert-butanol was added. The mixture was stirred for 2 h. The resulting white precipitate of [DDA]$_8$[β$_2$-SiW$_{11}$O$_{39}$] was collected by the filtration and washed with an excess amount of H$_2$O and a small quantity of diethyl ether, then dried in air. Yield: 0.9 g. IR spectrum (KBr, cm$^{-1}$): 2920, 2850,
2361, 1644, 1468, 1374, 988, 942, 874, 793, 744, 553.

\[ [(C_{18}H_{37})_2(CH_3)N]_8[\gamma-SiW_{10}O_{36}] : \]

K$_8[\gamma-SiW_{10}O_{36}] \cdot 12H_2O$ (0.74 g, 0.25 mmol) was dissolved in 12 ml H$_2$O. The solution was stirred vigorously. Dioctadecyl dimethyl ammonium.chloride (1.2 g, 2 mmol) dissolved in 10 ml tert-butanol was added to this solution. The mixture was stirred for 2 h. A white precipitate was collected by filtration and washed with an excess amount of H$_2$O and a small quantity of diethyl ether, then dried in air. Yield: 1.4 g. IR spectrum (KBr, cm$^{-1}$): 2920, 2850, 1643, 1468, 1368, 988, 941, 905, 969, 832, 741, 672, 557.

\[ [(C_{18}H_{37})_2(CH_3)N]_4[SiW_{12}O_{40}] : \]

A solution of H$_4$SiW$_{12}$O$_{40} \cdot XH_2O$ (0.72 g, 0.25 mmol) in 25ml water was stirred vigorously at 318 K. And to this solution 0.59 g (1.0 mmol) of dioctadecyl dimethyl ammonium.chloride dissolved in 15 ml tert-butanol was added. The mixture was stirred for 2 h at 318 K. A white precipitate of was collected by filtration and washed with an excess amount of H$_2$O and a small quantity of diethyl ether, and dried in vacuo. Yield: 0.80 g. IR spectrum (KBr, cm$^{-1}$): 2922, 2851, 1615, 1465, 1373, 1014, 972, 920, 883, 791, 532, 484.

\[ [(C_{18}H_{37})_2(CH_3)N]_3[PW_{12}O_{40}] : \]

A solution of H$_3$PW$_{12}$O$_{40} \cdot XH_2O$ (0.73 g, 0.25 mmol) in 25 ml water was stirred vigorously at 318 K. And to this solution 0.59 g (1.0 mmol) of dioctadecyl dimethyl ammonium.chloride dissolved in 15 ml tert-butanol was added. The mixture was stirred for 2 h at 318 K. A white precipitate of was collected by the filtration and washed with an excess amount of H$_2$O and a small quantity of diethyl ether, and dried in vacuo. Yield: 0.85 g. IR spectrum (KBr, cm$^{-1}$): 2920, 2851, 1666, 1368, 1080, 979, 897, 807, 723, 596, 518. $^{31}$P MAS NMR: -15.5 ppm.
Reference


Fig S1  XRD pattern of catalyst I.
Fig. S2 Raman spectrum of catalyst I

Fig. S3 UV-vis spectra of a) fresh catalyst I; b) catalyst I treated with H₂O₂
### Table S1  Epoxidation of 1-octene with H$_2$O$_2$ catalyzed by I$^a$

<table>
<thead>
<tr>
<th>Cycle times</th>
<th>Reaction time (h)</th>
<th>Conversion (mol%)</th>
<th>Selectivity (mol%)</th>
<th>Yield (mol%)</th>
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$^a$ Reaction conditions: 2.5 mmol 1-octene; 0.5 mmol H$_2$O$_2$; 20 μmol catalyst of I; 2 ml ethyl acetate; reaction temperature: 60 °C, Conversion (%) = consumed 1-octene (mol)/H$_2$O$_2$ used (mol) × 100. Yield (%) = 1-octene epoxide (mol)/H$_2$O$_2$ used (mol) × 100. Selectivity of epoxide was more than 99% for all cycles.
Table S2 Oxidation of thioanisole with hydrogen peroxide catalyzed by I for different cycles

<table>
<thead>
<tr>
<th>Cycle times</th>
<th>Reaction time (h)</th>
<th>Conversion (mol%)</th>
<th>Selectivity (mol%)</th>
<th>Yield (mol%)</th>
</tr>
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<td>5</td>
<td>2</td>
<td>100</td>
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</tr>
</tbody>
</table>

* Reaction conditions: time 2 h; 2mL solvent ethyl acetate; 10μmol (25 mg) cat I; 1 mmol substrate; 2 mmol H₂O₂; Reaction temperature: 333 K; Yield (%) = products (mol)/ substrate used (mol) × 100. Conversions and selectivity were determined by gas chromatography using an internal standard technique were based on the substrate.

Characterization of oxidation products:

The data (GC retention time, mass, and NMR) of epoxides were listed below:

\[
\text{GC (SE-54 capillary column, 30 m×0.32 mm×0.33 um, GC-9AM, Shimadzu Corporation)}
\]

carrier gas (N₂, 1.2 kg /cm²), column temperature (130 °C), injection temperature (220 °C), detection temperature (220 °C), retention time (2.3 min). MS (70 eV, EI): m/z (%): 124 (4) [M⁺], 123(6), 109(8), 107(14), 95 (20), 79 (64), 55 (89), 41(100). Colorless liquid,

\[
^1H \text{ NMR (300MHz, CDCl}_3): \delta = 5.34-5.51 (m, 1H), 4.61-4.71 (tt, J=9.3Hz, 2H)
\]
2.81-2.89 (m, 2H), 1.86-1.92 (m, 1H), 1.02-1.75 (m, 6H).

\[ \text{H} \quad \text{O} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \]

\[ \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{O} \]

\[ \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{O} \]

, limonene oxides

GC (SE-54 capillary column, 30 m×0.32 mm×0.33 um, GC-9AM, Shimadzu Corporation) carrier gas (N\(_2\), 1.2 kg /cm\(^2\)), initial column temperature (130 °C), final column temperature (180 °C), progress rate (20 °C/min), injection temperature (220 °C), detection temperature (220 °C), retention time (2.8 min). MS (70 eV, EI): m/z (%):152 (2) [M\(^+\)], 108(21), 94(40), 93(25), 81 (17), 67 (40), 55(21), 43(100), 41(41).

GC (SE-54 capillary column, 30 m×0.32 mm×0.33 um, GC-9AM, Shimadzu Corporation) carrier gas (N\(_2\), 1.2 kg /cm\(^2\)), column temperature (130 °C), injection temperature (220 °C), detection temperature (220 °C), retention time (3.2 min).MS (70 eV, EI): m/z (%):148 (5) [M\(^+\)], 120(13), 92 (13), 91(26), 82 (79), 81 (100), 79(23), 66(43), 39(27).

\(^1\)H NMR (300MHz, CDCl\(_3\)): \( \delta = 5.58-5.66 \) (m, 2H) , 2.94 (d, J=3.9Hz, 2H), 2.51(m, 2H), 2.68(m, 2H), 2.28(m, 2H), 1.38(d, J=9.6Hz, 1H), 0.78(t, 1H).

GC (SE-54 capillary column, 30m×0.32mm×0.33um, GC-9AM, Shimadzu Corporation) carrier gas (N\(_2\), 1.2kg /cm\(^2\)), column temperature (130 °C), injection temperature (220 °C), detection temperature (220 °C), retention time (3.5 min).MS (70 eV, EI): m/z (%):148 (7) [M\(^+\)], 91(10), 83(10), 82(10), 81 (15), 77 (7), 66(100), 39(17), 27(6).
1H NMR (300MHz, CDCl$_3$): $\delta$ = 6.10 (d, 2H), 3.19 (m, 1H), 3.02 (d, 1H), 2.75(d, 2H), 2.50(m, 2H), 1.80(m, 1H), 1.58(m, 2H), 1.26(d, 1H)

1-Methyl-4,5-epoxy-1-cyclohexene

GC (SE-54 capillary column, 30 m×0.32 mm×0.33 um, GC-9AM, Shimadzu Corporation)

carrier gas (N$_2$, 1.2 kg /cm$^2$), column temperature (130 °C), injection temperature (220 °C), detection temperature (220 °C), retention time (1.8 min). MS (70 eV, EI): m/z (%): 110 (100) [M$^+$], 95 (86), 91 (25), 82 (19), 81 (98), 80 (21), 79 (91), 77 (38).

1H NMR (300MHz, CDCl$_3$): $\delta$ = 5.01-5.07 (m, 1H), 4.09 (d, J = 6.9Hz, 2H), 2.46-2.51(m, 2H), 1.94-2.09 (m, 2H), 1.56(s, 3H).

1-Methyl-1,2-epoxy-4-cyclohexene

GC (SE-54 capillary column, 30 m×0.32 mm×0.33 um, GC-9AM, Shimadzu Corporation)

carrier gas (N$_2$, 1.2 kg /cm$^2$), column temperature (130 °C), injection temperature (220 °C), detection temperature (220 °C), retention time (1.5 min). MS (70 eV, EI): m/z (%): 110 [M$^+$] (4), 95 (8), 91 (10), 81(42), 67 (28), 50 (17), 43 (100).

1H NMR (300MHz, CDCl$_3$): $\delta$ = 5.33-5.36 (t, 2H), 2.95 (m,1H), 2.50-2.17 (m, 2H), 1.90-2.14 (m, 2H)$^\text{2}$, 1.22 (s, 3H).

2,3-Epoxy-3,7-dimethyloct-6-en-1-ol

GC (SE-54 capillary column, 30 m×0.32 mm×0.33 um, GC-9AM, Shimadzu Corporation)
carrier gas (N₂, 1.0 kg/cm²), initial column temperature (110 °C), final column temperature (200 °C), progress rate (20 °C/min), injection temperature (220 °C), detection temperature (220 °C), retention time (3.6 min). MS (70 eV, EI): m/z (%): 170 (2) [M⁺], 111 (21), 94 (40), 93 (25), 81 (15), 68 (40), 59 (100), 55 (48), 43 (60), 41 (31). ¹³C NMR (100 MHz, CDCl₃): 132.04, 123.29, 63.07, 61.32, 61.14, 38.43, 25.56, 23.60, 17.55, 16.66.

¹H NMR (400 MHz, CDCl₃): 5.08 (t, J = 1.2 Hz, 1H), 3.80-3.83 (m, 1H), 3.64-3.69 (m, 1H), 2.97-2.99 (m, 1H), 2.59 (s, br, 1H), 2.05-2.11 (m, 2H), 1.64-1.70 (m, 4H), 1.61 (s, 3H), 1.43-1.51 (m, 1H), 1.30 (s, 3H).

6,7-Epoxy-3,7-dimethyloct-2-en-1-ol

GC (SE-54 capillary column, 30 m×0.32 mm×0.33 um, GC-9AM, Shimadzu Corporation)
carrier gas (N₂, 1.0 kg/cm²), initial column temperature (110 °C), final column temperature (200 °C), progress rate (20 °C/min), injection temperature (220 °C), detection temperature (220 °C), retention time (3.8 min). ¹³C NMR (100 MHz, CDCl₃): 138.28, 124.04, 63.99, 59.09, 58.36, 36.16, 27.04, 24.75, 18.65, 16.16.

¹H NMR (400 MHz, CDCl₃): 5.45 (t, J = 8.8 Hz, 1H), 4.15 (d, J = 9.6 Hz, 2H), 2.72 (t, J = 8.4 Hz, 1H), 2.09-2.24 (m, 2H), 1.86 (s, br, 1H), 1.70 (s, 3H), 1.63-1.67 (m, 2H), 1.31 (s, 3H), 1.27 (s, 3H).

cyclopentene oxide

GC (SE-54 capillary column, 30 m×0.32 mm×0.33 um, GC-9AM, Shimadzu Corporation)
carrier gas (N₂, 1.2 kg/cm²), column temperature (100 °C), injection temperature (220 °C), detection temperature (220 °C), retention time (1.3 min). MS (70 eV, EI): m/z (%): 84 (10) [M⁺],
83 (38) [M⁺⁻], 69 (13), 56 (42), 55 (100), 41(54), 39 (30), 27(22)

Cyclohexene oxide

GC (SE-54 capillary column, 30 m×0.32 mm×0.33 um, GC-9AM, Shimadzu Corporation)
carrier gas (N₂, 1.2 kg /cm²), column temperature (110 °C), injection temperature (220 °C),
detection temperature (220 °C), retention time (1.8 min).MS (70 eV, EI): m/z (%): 98 (18) [M⁺],
83 (100), 70 (28), 69 (35), 57 (45), 54(58), 42 (60), 39(43).

Cyclooctene oxide

GC (SE-54 capillary column, 30 m×0.32 mm×0.33 um, GC-9AM, Shimadzu Corporation)
carrier gas (N₂, 1.2kg /cm²), column temperature (110 °C), injection temperature (220 °C),
detection temperature (220 °C), retention time (3.5 min).MS (70 eV, EI): m/z (%): 126 (4) [M⁺],
97 (22), 83 (28), 67 (60), 57 (53), 55(100), 54(41), 41(75).

Styrene oxide

GC (SE-54 capillary column, 30 m×0.32 mm×0.33 um, GC-9AM, Shimadzu Corporation)
carrier gas (N₂, 1.2 kg /cm²), column temperature (130 °C), injection temperature (220 °C),
detection temperature (220 °C), retention time (2.0 min).MS (70 eV, EI): m/z (%): 120 (44) [M⁺],
119 (22), 92 (31), 91 (100), 90 (29), 89(28), 65(17), 63(10).

Norbornene oxide

GC (SE-54 capillary column, 30 m×0.32 mm×0.33 um, GC-9AM, Shimadzu Corporation)
carrier gas (N₂, 1.2 kg /cm²), column temperature (130 °C), injection temperature (220 °C),
detection temperature (220 °C), retention time (1.9 min).MS (70 eV, EI): m/z (%): 110 (10) [M⁺],
109 (7), 95 (19), 92 (15), 82 (29), 81(100), 79(65), 67(40), 55(43), 54(31), 39(25).
a-Methylstyrene oxide

GC (SE-54 capillary column, 30 m×0.32 mm×0.33 um, GC-9AM, Shimadzu Corporation)
carrier gas (N₂, 1.2 kg/cm²), column temperature (130 °C), injection temperature (220 °C),
detection temperature (220 °C), retention time (2.8 min).MS (70 eV, EI): m/z (%): 134 (37) [M⁺],
133(65), 105 (100), 103(40), 91 (15), 77 (29), 51(14).

1-Methylcyclohexene oxide

GC (SE-54 capillary column, 30 m×0.32 mm×0.33 um, GC-9AM, Shimadzu Corporation)
carrier gas (N₂, 1.2kg/cm²), column temperature (130 °C), injection temperature (220 °C),
detection temperature (220 °C), retention time (1.4 min).MS (70 eV, EI): m/z (%): 112 (18) [M⁺],
97(82), 83 (17), 69(25), 55(48), 43 (100), 41(50).

Indene oxide

GC (SE-54 capillary column, 30 m×0.32 mm×0.33 um, GC-9AM, Shimadzu Corporation)
carrier gas (N₂, 1.2 kg /cm²), column temperature (180 °C), injection temperature (220 °C),
detection temperature (220 °C), retention time (4.2 min).MS (70 eV, EI): m/z (%): 132 (30) [M⁺],
104(100), 103 (27), 78(27), 77(17), 63 (13), 52 (12), 51(29).

Propylene oxide

GC (SE-54 capillary column, 30 m×0.32 mm×0.33 um, GC-9AM, Shimadzu Corporation)
carrier gas (N₂, 1.2 kg /cm²), column temperature (100 °C), injection temperature (220 °C),
detection temperature (220 °C), retention time (1.8 min).

1-Hexene oxide
GC (SE-54 capillary column, 30 m×0.32 mm×0.33 um, GC-9AM, Shimadzu Corporation)
carrier gas (N₂, 1.2 kg /cm²), column temperature (130 °C), injection temperature (220 °C),
detection temperature (220 °C), retention time (1.3 min).MS (70 eV, EI): m/z (%): 100 (3) [M⁺],
85(2), 71 (100), 58(32), 55(41), 42(65), 41 (71), 39(33).

1,2-epoxyheptane

1-Octene oxide

2-nonyloxirane

1,2-Epoxydodecane
detection temperature (220 °C), retention time (3.8 min). MS (70 eV, EI): m/z (%): 184 (2) [M+],
95(21), 82(35), 71(82), 69 (46), 55(78), 43(75), 41 (100), 29(30).

, 1,2-epoxyhexadecane

GC (SE-54 capillary column, 30 m×0.32 mm×0.33 μm, GC-9AM, Shimadzu Corporation)
carrier gas (N₂, 1.2 kg/cm²), column temperature (180 °C), injection temperature (220 °C),
detection temperature (220 °C), retention time (6.9 min). MS (70 eV, EI): m/z (%): 240 (2) [M+],
180(4), 109(23), 96(60), 82 (90), 68(55), 57(46), 55 (85), 41(100), 29 (51).

, cis-2,3-Epoxyheptane

GC (SE-54 capillary column, 30 m×0.32 mm×0.33 μm, GC-9AM, Shimadzu Corporation)
carrier gas (N₂, 1.2 kg/cm²), column temperature (130 °C), injection temperature (220 °C),
detection temperature (220 °C), retention time (1.8 min). MS (70 eV, EI): m/z (%): 114 (9) [M+],
85(87), 71 (54), 57(72), 55 (86), 45 (100), 42 (96), 41 (80), 29(60).

, 2,3-epoxy-1-propanol

GC (SE-54 capillary column, 30 m×0.32 mm×0.33 μm, GC-9AM, Shimadzu Corporation)
carrier gas (N₂, 1.2 kg/cm²), column temperature (60 °C), injection temperature (220 °C),
detection temperature (220 °C), retention time (1.3 min). MS (70 eV, EI): m/z (%): 74 (4) [M+],
45(85), 44 (100), 42(72), 31 (53), 29 (41), 26 (78), 15 (10).

epichlorohydrin

GC (SE-54 capillary column, 30 m×0.32 mm×0.33 μm, GC-9AM, Shimadzu Corporation)
carrier gas (N₂, 1.2 kg/cm²), column temperature (50 °C), injection temperature (220 °C),

15
detection temperature (220 °C), retention time (1.6 min). MS (70 eV, EI): m/z (%): 92 (2) [M+], 64 (6), 57 (100), 49 (25), 42 (11), 31 (30), 29 (22), 27 (42).

\[ \text{[1]} \]

\[ \text{[2]} \]

\[ \text{[3]} \]

\[ \text{[1,2]} \]

\[ \text{[1,3]} \]

\[ \text{[3]} \]

1H NMR (CDCl₃, 400 MHz) δ1.31-1.34 (t, J=15.2 Hz, 6H), 2.91-2.96 (m, 4H).

1H NMR (CDCl₃, 400 MHz) δ1.04-1.08 (m, 6H), 1.80-1.90 (m, 4H), 2.89-2.93 (m, 4H).

1H NMR (CDCl₃, 400 MHz) δ 0.79-0.83 (t, J= 14.4Hz, 6H), 1.30-1.36 (m, 4H), 1.63-1.67 (t, J= 14.4Hz, 4H), 2.81-2.85 (t, J= 15.6 Hz, 4H).

1H NMR (CDCl₃, 400 MHz) δ 3.07 (s, 3H), 7.57-7.61 (t, J= 15.2 Hz, 2H), 7.65-7.69 (t, J= 14.8Hz, 1H ), 7.95-7.97 (t, J= 8.8Hz, 2H).

1H NMR (CDCl₃, 400 MHz) δ3.04 (d, J= 2.4 Hz, 3H), 7.68-7.71 (m, 2H).
\[ \text{H NMR (CDCl}_3, 400 \text{ MHz)} \delta 2.39 (s, 3\text{H}), 2.98 (d, J=1.2 \text{ Hz}, 3\text{H}), 7.30-7.32 \text{ (t, J=8 Hz, 2\text{H})}, 7.75-7.77 \text{ (t, J=8 Hz, 2\text{H})} \]

References