Polystyrene-supported bifunctional resorcinarenes as cheap, metal-free and recyclable catalysts for epoxide/CO$_2$ coupling reactions

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1. General information

Unless otherwise noted, all commercial reagents were used as received without further purification or drying, including CO\textsubscript{2} (purchased from PRAX-38 AIR). Flash chromatography was carried out using 60 mesh silica gel and dry-packed columns. Thin layer chromatography was carried out using Merck TLC Silicagel 60 F254 aluminum sheets. Components were visualized by UV light (\(\lambda = 254\) nm) and stained with \(p\)-anisaldehyde or phosphomolybdic dip.

NMR spectra were recorded at 298 K on a Fourier 300 MHz Bruker, a Bruker Avance 400 Ultrashield or a Bruker Avance 500 Ultrashield apparatus. Chemical shifts are reported in ppm relative to the residual solvent peaks in CDCl\textsubscript{3} (\(\delta = 7.26\) ppm) and (CD\textsubscript{3})\textsubscript{2}CO (\(\delta = 2.05\) ppm). Elemental analysis was performed by MEDAC Ltd, United Kingdom. IR spectra were recorded on a Bruker Tensor 27 FT-IR spectrometer.

2. General Protocol for the Carbonate Synthesis (COC1-12)

![Reaction Scheme]

Typically, the reaction was performed in a 30 mL steel autoclave where the epoxide (S1-12) (8.3 mmol, 1 equiv.) and catalyst 14 (1.0 mol%) were added as liquid and solid respectively. The autoclave was then subjected to three cycles of pressurization and depressurization with CO\textsubscript{2}. Finally, the autoclave was charged with 0.5 Mpa (5 bar) of CO\textsubscript{2}, heated to 80 °C, and the contents was stirred for 18 hours. Upon completion of the reaction, the autoclave was cooled to room temperature and carefully depressurized. The volatiles were removed under reduced pressure, and the product was purified by flash column chromatography (typically 1:1 cyclohexane/ethyl acetate as eluent) to afford the pure cyclic carbonate COC1-12.
2.1. Characterization of Cyclic Carbonates

**1,2-hexylene carbonate, COC1**: Following the general procedure using 1,2-epoxypentane S1 (8.3 mmol, 1 equiv.), catalyst 14 (0.083 mmol, 0.01 equiv.) and CO₂ (0.5 MPa) to afford 1,2-hexylene carbonate COC1 (7.72 mmol, 93% yield) as a colorless oil. The spectroscopic data correspond to those previously reported in the literature.¹ ² ³ ¹H-NMR (400 MHz, CDCl₃): δ = 0.90 (t, J = 6.0 Hz, 3H), 1.25-1.48 (m, 4H), 1.59-1.83 (m, 2H), 4.05 (t, J = 8.0 Hz, 1H), 4.51 (dd, J = 8.0 Hz, 1H), 4.68 (m, 7.5 Hz, 1H). ¹³C-NMR (100 MHz, CDCl₃): δ = 13.9, 22.3, 26.6, 33.7, 69.5, 77.2, 155.1. IR: 1784 cm⁻¹ (C=O).

**Allyl glycidyl carbonate, COC2**: Following the general procedure using allyl glycidyl oxirane S2 (8.3 mmol, 1 equiv.), catalyst 14 (0.083 mmol, 0.01 equiv.) and CO₂ (0.5 MPa) to afford allyl glycidyl carbonate COC2 (8.05 mmol, 97% yield) as a colorless oil. The spectroscopic data correspond to those previously reported in the literature.¹ ² ³ ¹H-NMR (400 MHz, CDCl₃): δ = 3.62 (dd, J = 3.8; 11.0 Hz, 1H), 3.69 (dd, J = 4.1; 11.0 Hz, 1H), 3.99-4.12 (m, 2H), 4.40 (dd, J = 6.1; 8.4 Hz, 1H), 4.50 (t, 8.4 Hz, 1H), 4.82 (m, 1H), 5.20-5.32 (m, 2H), 5.81-5.92 (m, 1H). ¹³C-NMR (100 MHz, CDCl₃): δ = 66.4, 69.0, 72.8, 75.1, 118.1, 133.7, 155.1. IR: 1782 cm⁻¹ (C=O)

**Styrene carbonate, COC3**: Following the general procedure using styrene oxide S3 (8.3 mmol, 1 equiv.), catalyst 14 (0.083 mmol, 0.01 equiv.) and CO₂ (0.5 MPa) to afford styrene carbonate COC3 (6.72 mmol, 81% yield) as a white solid. The spectroscopic data correspond to those previously reported in the literature.¹ ² ³ ¹H-NMR (400 MHz, CDCl₃): δ = 4.35 (dd, J = 7.8; 8.6 Hz, 1H), 4.80 (t, J = 8.4 Hz, 1H), 5.68 (t, J = 8.0 Hz, 1H), 7.33-7.49 (m, 5H). ¹³C-NMR (100 MHz, CDCl₃): δ = 71.3, 78.1, 126.0, 129.8, 129.9, 135.9, 155.9. IR: 1776 cm⁻¹ (C=O)

**Propylene carbonate, COC4**: Following the general procedure using propylene oxide S4 (8.3 mmol, 1 equiv.), catalyst 14 (0.083 mmol, 0.01 equiv.) and CO₂ (0.5 MPa) to afford propylene carbonate COC4 (7.30 mmol, 88% yield) as a colorless oil. The spectroscopic data correspond to those previously reported in the literature.¹ ² ³ ¹H-NMR (400 MHz, CDCl₃): δ = 1.49 (d, J = 6.3 Hz, 3H), 4.02 (dd, J =
7.2; 8.4 Hz, 1H), 4.55 (dd, J = 7.7; 8.4 Hz, 1H), 4.80-4.90 (m, 1H). $^{13}$C-NMR (100 MHz, CDCl$_3$): $\delta$ = 19.5, 70.8, 73.6, 155.1. IR: 1782 cm$^{-1}$ (C=O)

3-phenoxypyropylene carbonate, COC5: Following the general procedure using 3-phenoxypyropylene oxide S5 (8.3 mmol, 1 equiv.), catalyst 14 (0.083 mmol, 0.01 equiv.) and CO$_2$ (0.5 MPa) to afford 3-phenoxypyropylene carbonate COC5 (7.89 mmol, 95% yield) as a white solid. The spectroscopic data correspond to those previously reported in the literature. $^{1}$H-NMR (400 MHz, CDCl$_3$): $\delta$ = 4.18 (dd, J = 10.5, 3.6 Hz, 1H), 4.27 (dd, J = 10.6, 4.4 Hz, 1H), 4.53-4.67 (m, 2H), 5.02-5.09 (m, 1H), 6.94 (d, J = 8.0 Hz, 2H), 7.04 (t, J = 8.0 Hz, 1H), 7.34 (t, J = 8.0 Hz, 2H). $^{13}$C-NMR (100 MHz, CDCl$_3$): $\delta$ = 66.4, 67.0, 74.2, 114.8, 122.2, 129.8, 157.9. IR: 1781 cm$^{-1}$ (C=O).

3-methoxypypropylene carbonate, COC6: Following the general procedure using 3-methoxypypropylene oxide S6 (8.3 mmol, 1 equiv.), catalyst 14 (0.083 mmol, 0.01 equiv.) and CO$_2$ (0.5 MPa) to afford 3-methoxypypropylene carbonate S6 (7.55 mmol, 91% yield) as a colorless oil. The spectroscopic data correspond to those previously reported in the literature. $^{1,2,3}$H-NMR (400 MHz, CDCl$_3$): $\delta$ = 3.42 (s, 3H), 3.59 (dd, J= 11.0, 3.8 Hz, 1H), 3.66 (dd, J= 11.0, 3.8 Hz, 1H), 4.37 (dd, J = 6.1; 8.4 Hz, 1H), 4.49 (t, J = 8.4 Hz, 1H), 4.76-4.84 (m, 1H). $^{13}$C-NMR (100 MHz, CDCl$_3$): $\delta$ = 59.8, 66.4, 71.8, 75.1, 155.1. IR: 1780 cm$^{-1}$ (C=O).

1,2-octylene carbonate, COC7: Following the general procedure using 1,2-octylene oxide S7 (8.3 mmol, 1 equiv.), catalyst 14 (0.083 mmol, 0.01 equiv.) and CO$_2$ (0.5 MPa) to afford 1,2-octylene carbonate COC7 (7.05 mmol, 85% yield) as a yellow oil. The spectroscopic data correspond to those previously reported in the literature. $^{1}$H-NMR (400 MHz, CDCl$_3$): $\delta$ = 0.88 (t, J = 7.0 Hz, 3H), 1.22-1.54 (m, 8H), 1.62-1.87 (m, 2H), 4.06 (dd, J = 7.2; 8.4 Hz, 1H), 4.52 (dd, J = 7.8; 8.4, Hz, 1H), 4.70 (m, 7.5 Hz, 1H). $^{13}$C-NMR (100 MHz, CDCl$_3$): $\delta$ = 14.2, 22.7, 24.3, 28.9, 31.7, 33.9, 69.6, 155.2. IR: 1788 cm$^{-1}$ (C=O).
3-chloropropylene carbonate, COC8: Following the general procedure using 3-chloropropylene oxide S8 (8.3 mmol, 1 equiv.), catalyst 14 (0.083 mmol, 0.01 equiv.) and CO2 (0.5 MPa) to afford 3-chloropropylene carbonate COC8 (7.80 mmol, 94% yield) as a colorless oil. The spectroscopic data correspond to those previously reported in the literature.\(^1\)\(^2\)\(^3\) \(\text{H-NMR (400 MHz, CDCl}_3\): } \delta = 3.68-3.80 (m, 2H), 4.41 (dd, J = 5.7; 8.9 Hz, 1H), 4.59 (dd, J = 8.2; 8.9 Hz, 1H), 4.91-5.0 (m, 1H). \(\text{C-NMR (100 MHz, CDCl}_3\): } \delta = 43.5, 66.9, 74.3, 154.0. \text{IR: } 1778 \text{ cm}^{-1} (\text{C=O}).

Glycerol carbonate, COC9: Following the general procedure using glycidol S9 (8.3 mmol, 1 equiv.), catalyst 14 (0.083 mmol, 0.01 equiv.) and CO2 (0.5 MPa) to afford glycerol carbonate COC9 (6.64 mmol, 80% yield) as a colorless oil. The spectroscopic data correspond to those previously reported in the literature.\(^2\)\(^3\) \(\text{H-NMR (400 MHz, CDCl}_3\): } \delta = 2.68 (dd, J = 7.0; 5.8 Hz, 1H), 3.70 (ddd, J = 12.9; 6.8; 3.5 Hz, 1H), 3.98 (ddd, J = 12.8; 5.5; 3.0 Hz, 1H), 4.45 (dd, J = 9.3; 5.8 Hz, 1H), 4.52 (t, J = 8.3 Hz, 1H), 4.77–4.89 (m, 1H). \(\text{C-NMR (100 MHz, CDCl}_3\): } \delta = 61.8, 66.1, 76.7, 155.6. \text{IR: } 1762 \text{ cm}^{-1} (\text{C=O}).

Cyclohexene carbonate, COC10: Following the general procedure using cyclohexene oxide S10 (8.3 mmol, 1 equiv.), catalyst 14 (0.249 mmol, 0.03 equiv.) and CO2 (0.5 MPa) at 100 °C for 64 hours to afford cyclohexene carbonate COC10 (3.40 mmol, 41% yield, 68% selectivity, 65% conversion) as a yellow oil. The spectroscopic data correspond to those previously reported in the literature.\(^1\)\(^2\) \(\text{H-NMR (400 MHz, CDCl}_3\): } \delta = 1.29-1.50 (m, 2H), 1.56-1.72 (m, 2H), 1.84-1.93 (m, 4H), 4.65-4.71 (m, 2H). \(\text{C-NMR (100 MHz, CDCl}_3\): } \delta = 19.1, 26.8, 75.9, 155.5. \text{IR: } 1785 \text{ cm}^{-1} (\text{C=O}).

Cyclopentene carbonate, COC11: Following the general procedure using cyclopentene oxide S11 (8.3 mmol, 1 equiv.), catalyst 14 (0.249 mmol, 0.03 equiv.) and CO2 (0.5 MPa) at 100 °C for 64 hours to afford cyclopentene carbonate COC11 (5.73 mmol, 69% yield, 76% selectivity, 95% conversion) as a white solid. The spectroscopic data correspond to those previously reported in the literature.\(^1\) \(\text{H-NMR (400 MHz, CDCl}_3\): } \delta = 1.60-1.87 (m, 4H), 2.08-2.22 (m, 2H), 5.01-5.14 (m, 2H). \(\text{C-NMR (100 MHz, CDCl}_3\): } \delta = 21.7, 33.3, 81.9, 155.6. \text{IR: } 1780 \text{ cm}^{-1} (\text{C=O}).
Tetrahydrofuro[3,4-d][1,3]dioxol-2-one, COC12: Following the general procedure using 3,4-epoxytetrahydrofuran S12 (8.3 mmol, 1 equiv.), catalyst 14 (0.249 mmol, 0.03 equiv.) and CO$_2$ (0.5 MPa) at 100 °C for 64 hours to afford tetrahydrofuro[3,4-d][1,3]dioxol-2-one COC12 (4.90 mmol, 59% yield, 86% selectivity, 71% conversion) as a white solid. The spectroscopic data correspond to those previously reported in the literature.$^1$ $^1$H-NMR (400 MHz, CDCl$_3$): $\delta = 3.53-3.61$ (m, 2H), 4.09-4.36 (m, 2H), 5.20 (d, $J = 2.2$ Hz, 2H). $^{13}$C-NMR (100 MHz, CDCl$_3$): $\delta = 73.1$, 80.1, 154.5. IR: 1779 cm$^{-1}$ (C=O).


In a two neck 100 mL round bottom flask, one equivalent of resorcinol (50 mmol) in a solution of ethanol (10 mL) and water (10 mL) and concentrated HCl (5 mL) were added and cooled to 0 °C. Then the aldehyde reagent (50 mmol, 1 equiv.) was added dropwise to the reaction mixture. The resulting solution was stirred at 75 °C for 48 hours. Upon cooling to room temperature, the desired resorcin[4]arene precipitated. The solid product was filtered and washed with water and ethanol.


Resorcin[4]arene 1: Following the general procedure using resorcinol (50 mmol, 1 equiv.) and butyraldehyde (50 mmol, 1 equiv.) to afford resorcin[4]arene 1 (6.0 mmol, 48% yield) as a pale yellow solid. $^1$H-NMR (400 MHz, Acetone-$_d_6$): $\delta = 0.95$ (t, $J = 7.4$ Hz, 12 H), 1.36 -- 1.24 (m, 8 H), 2.35 -- 2.22 (m, 8 H), 4.33 (t, $J = 7.9$ Hz, 4 H), 6.23 (s, 4 H), 7.58 (s, 4 H), 8.42 (s, 8 H). $^{13}$C-NMR (100 MHz, Acetone-$_d_6$): $\delta = 14.4$, 22.0, 33.0, 36.5, 103.8, 125.3, 125.7, 152.7. Elemental analysis: Calculated for C$_{40}$H$_{36}$O$_8$·½H$_2$O: C, 72.65; H, 7.39. Found: C, 72.88; H, 7.38. Melting point: >350 °C.
Resorcin[4]arene 2: Following the general procedure using resorcinol (50 mmol, 1 equiv.) and valeraldehyde (50 mmol, 1 equiv.) to afford resorcin[4]arene 2 (6.4 mmol, 51% yield) as a yellow solid. \(^1\)H-NMR (400 MHz, Acetone-\(d_6\)): \(\delta = 0.89\) (t, \(J = 7.2\) Hz, 12 H), 1.50 – 1.17 (m, 16 H), 2.3 (m, 8 H), 4.3 (t, \(J = 7.9\) Hz, 4 H), 6.24 (s, 4 H), 7.56 (s, 4 H), 8.43 (s, 8 H). \(^{13}\)C-NMR (100 MHz, Acetone-\(d_6\)): \(\delta = 14.6, 23.4, 31.3, 34.0, 103.9, 125.3, 125.5, 152.7\). **Elemental analysis:** Calculated for C\(_{44}\)H\(_{56}\)O\(_8\)·\(\frac{1}{2}\)H\(_2\)O: C, 73.20; H, 7.97. Found: C, 73.03; H, 8.80. **Melting point:** >350 °C.

Resorcin[4]arene 3: Following the general procedure using resorcinol (50 mmol, 1 equiv.) and heptaldehyde (50 mmol, 1 equiv.) to afford resorcin[4]arene 3 (5.9 mmol, 47% yield) as a yellow solid. \(^1\)H-NMR (400 MHz, Acetone-\(d_6\)): \(\delta = 0.89\) (t, \(J = 6.8\) Hz, 12 H), 1.45 – 1.23 (m, 32 H), 2.36-2.21 (m, 8 H), 4.31 (t, \(J = 7.9\) Hz, 4 H), 6.24 (s, 4 H), 7.55 (s, 4 H), 8.48 (s, 8 H). \(^{13}\)C-NMR (100 MHz, Acetone-\(d_6\)): \(\delta = 14.3, 23.3, 28.9, 30.0, 32.7, 34.2, 34.3, 103.5, 125.1, 125.3, 152.6\). **Elemental analysis:** Calculated for C\(_{52}\)H\(_{72}\)O\(_8\)·\(\frac{1}{2}\)H\(_2\)O: C, 74.88; H, 8.82. Found: C, 74.50; H, 8.46. **Melting point:** 323 °C.

Resorcin[4]arene 4: Following the general procedure using resorcinol (50 mmol, 1 equiv.) and lauric aldehyde (50 mmol, 1 equiv.) to afford resorcin[4]arene 4 (6.5 mmol, 52% yield) as a yellow solid. \(^1\)H-NMR (400 MHz, Acetone-\(d_6\)): \(\delta = 0.89\) (t, \(J = 6.7\) Hz, 12 H), 1.30 (m, 72 H), 2.09 (m, 8 H), 2.39 (M, 8 H), 4.30 (t, \(J = 7.9\) Hz, 4 H), 6.24 (s, 4 H), 7.53 (s, 4 H), 8.51 (s, 8 H). \(^{13}\)C-NMR (100 MHz, Acetone-\(d_6\)): \(\delta = 14.4, 23.4, 29.1, 29.3, 30.2, 30.4, 30.5, 30.6, 30.7, 32.7, 34.4, 34.5, 103.6, 125.5, 125.6, 152.9\). **Elemental analysis:** Calculated for C\(_{72}\)H\(_{112}\)O\(_8\)·2H\(_2\)O: C, 78.14; H, 10.29. Found: C, 77.99; H, 9.43. **Melting point:** 304 °C.
4. General Protocol for the Synthesis of Tetrabenzoxazines (5-11)

Into a solution of resorcin[4]arene 1-4 (2 mmol, 1 equiv.) and excess of formaldehyde (5 ml) in ethanol (50 ml), the corresponding primary amine (10 mmol, 1.25 equiv.) was added dropwise. The reaction mixture was stirred at room temperature for 24 hours. The solid product was filtered off, washed with cold ethanol/water (9:1 v/v) and dried to give the tetrabenzoxazine 5-11.

4.1. Characterization of Tetrabenzoxazines

Tetrabenzoxazine 5: Following the general procedure using propyl resorcin[4]arene 1 (2 mmol, 1 equiv.) and butylamine (10 mmol, 1.25 equiv.) to afford tetrabenzoxazine 5 (1.48 mmol, 74% yield) as a yellow solid. $^1$H-NMR (400 MHz, CDCl$_3$): $\delta$ = 0.90 (t, $J$ = 7.3 Hz, 12 H), 0.97 (t, $J$ = 7.3 Hz, 12 H), 1.2 – 1.41 (m, 16 H), 1.42 – 1.61 (m, 8 H), 2.18 (m, 8 H), 2.63 (m, 8 H), 3.78 (d, $J$ = 17.3 Hz, 4 H), 3.98 (d, $J$ = 17.3 Hz, 4 H), 4.24 (t, $J$ = 7.9 Hz 4 H), 4.91 (q, $J$ = 8.0 Hz, 8 H), 7.12 (s, 4 H), 7.74 (s, 4 H).

$^{13}$C-NMR (100 MHz, CDCl$_3$): $\delta$ = 14.1, 14.2, 20.4, 21.2, 30.1, 32.4, 35.7, 46.5, 51.4, 82.9, 108.5, 121.3, 123.5, 124.4, 148.0, 149.8. Elemental analysis: Calculated for C$_{64}$H$_{92}$N$_4$O$_8$·H$_2$O: C, 72.28; H, 8.91; N, 5.27. Found: C, 72.57; H, 8.76; N, 4.87.
**Tetrabenzoxazine 6:** Following the general procedure using butyl resorcin[4]arene 2 (2 mmol, 1 equiv.) and propylamine (10 mmol, 1.25 equiv.) to afford tetrabenzoxazine 6 (1.52 mmol, 76% yield) as an orange solid. $^1$H-NMR (400 MHz, CDCl$_3$): $\delta =$ 0.90 (m, 24H), 1.18 – 1.61 (m, 24 H), 2.18 (m, 8 H), 2.58 (m, 8 H), 3.77 (d, $J = 17.3$ Hz, 4 H), 3.95 (d, $J = 17.3$ Hz 4 H), 4.21 (t, $J = 7.8$ Hz, 4 H), 4.90 (q, $J = 9.6$ Hz, 8 H), 7.11 (s, 4 H), 7.78 (s, 4 H). $^{13}$C-NMR (100 MHz, CDCl$_3$): $\delta =$ 11.7, 14.3, 21.3, 22.9, 30.4, 32.8, 33.4, 46.5, 53.6, 83.3, 108.6, 121.2, 123.6, 124.4, 148.2, 149.8. **Elemental analysis:** Calculated for C$_{64}$H$_{92}$N$_4$O$_8$·1/3H$_2$O: C, 73.11; H, 8.88; N, 5.33. Found: C, 72.93; H, 9.51; N, 4.89.

**Tetrabenzoxazine 7:** Following the general procedure using resorcin[4]arene 2 (2 mmol, 1 equiv.) and butylamine (10 mmol, 1.25 equiv.) to afford tetrabenzoxazine 7 (1.76 mmol, 88% yield) as a pinkish yellow solid. $^1$H-NMR (400 MHz, CDCl$_3$): $\delta =$ 0.93 (m, 24 H), 1.19 – 1.6 (m, 32 H), 2.18 (m, 8 H), 2.62 (m, 8 H), 3.76 (d, $J = 17.3$ Hz, 4 H), 3.96 (d, $J = 17.3$ Hz, 4 H), 4.21 (t, $J = 7.8$ Hz, 4 H), 4.91 (q, $J = 8.0$ Hz, 8 H), 7.11 (s, 4 H), 7.78 (s, 4 H). $^{13}$C-NMR (100 MHz, CDCl$_3$): $\delta =$ 13.9, 14.2, 20.3, 22.7, 30.1, 30.3, 32.7, 33.3, 46.4, 51.2, 83.9, 108.5, 121.1, 123.5, 124.3, 148.0, 149.7. **Elemental analysis:** Calculated for C$_{68}$H$_{100}$N$_4$O$_8$·½H$_2$O: C, 73.54; H, 9.17; N, 5.04. Found: C, 73.69; H, 9.25; N, 4.74.
Tetrabenzoxazine 8: Following the general procedure using resorcin[4]arene 2 (2 mmol, 1 equiv.) and hexylamine (10 mmol, 1.25 equiv.) to afford tetrabenzoxazine 8 (1.74 mmol, 87% yield) as a pinkish yellow solid. \(^1\)H-NMR (400 MHz, CDCl\(_3\)): \(\delta = 0.88\) (m, 24 H), 1.21 – 1.56 (m, 48 H), 2.16 (m, 8 H), 2.62 (m, 8 H), 3.76 (d, \(J = 17.3\) Hz, 4 H), 3.96 (d, \(J = 17.3\) Hz, 4 H), 4.21 (t, \(J = 7.8\) Hz, 4 H), 4.9 (q, \(J = 9.6\) Hz, 8 H), 7.10 (s, 4 H), 7.79 (s, 4 H). \(^{13}\)C-NMR (100 MHz, CDCl\(_3\)): \(\delta = 14.0, 14.2, 22.6, 22.7, 26.8, 28.0, 30.3, 31.7, 32.7, 33.3, 46.4, 51.6, 83.0, 108.6, 121.0, 123.5, 124.3, 148.0, 149.6\). **Elemental analysis**: Calculated for C\(_{76}\)H\(_{116}\)N\(_4\)O\(_8\): C, 75.21; H, 9.63; N, 4.62. Found: C, 74.78; H, 9.21; N, 4.60.

Tetrabenzoxazine 9: Following the general procedure using resorcin[4]arene 2 (2 mmol, 1 equiv.) and benzylamine (10 mmol, 1.25 equiv.) to afford tetrabenzoxazine 9 (1.66 mmol, 83% yield) as an orange solid. \(^1\)H-NMR (400 MHz, CDCl\(_3\)): \(\delta = 0.95\) (t, \(J = 7.2\) Hz, 12 H), 1.25 - 1.49 (m, 16 H), 2.23 (m, 8 H), 3.68 - 410 (m, 16 H), 4.27 (t, \(J = 7.7\) Hz, 4 H), 4.87 (q, \(J = 9.6\) Hz, 8 H), 7.16 - 7.35 (m, 20 H), 7.72 (s, 4 H). \(^{13}\)C-NMR (100 MHz, CDCl\(_3\)): \(\delta = 14.2, 22.7, 30.6, 32.7, 33.6, 46.7, 55.9, 82.4, 108.6, 121.4, 123.9, 124.4, 127.5, 128.5, 129.1, 137.9, 148.2, 149.9\). **Elemental analysis**: Calculated for C\(_{80}\)H\(_{92}\)N\(_4\)O\(_8\)·H\(_2\)O: C, 76.52; H, 7.55; N, 4.46. Found: C, 76.75; H, 7.41; N, 4.69.
Tetrabenzoxazine 10: Following the general procedure using resorcin[4]arene 3 (2 mmol, 1 equiv.) and butylamine (10 mmol, 1.25 equiv.) to afford tetrabenzoxazine 10 (1.6 mmol, 80% yield) as a yellow solid. $^1$H-NMR (400 MHz, CDCl$_3$): $\delta = 0.88$ (m, 24 H), 1.17 – 1.57 (m, 48 H), 2.17 (m, 8 H), 2.61 (m, 8 H), 3.76 (d, $J = 17.3$ Hz, 4 H), 3.96 (d, $J = 17.3$ Hz, 4 H), 4.21 (t, $J = 7.8$ Hz, 4 H), 4.90 (q, $J = 9.6$ Hz, 8 H), 7.10 (s, 4 H), 7.77 (s, 4 H). $^{13}$C-NMR (100 MHz, CDCl$_3$): $\delta =$ 14.1, 14.2, 20.5, 22.8, 28.2, 29.5, 30.3, 32.1, 32.8, 33.8, 46.6, 51.4, 83.3, 108.6, 121.2, 123.6, 124.5, 148.2, 149.8. Elemental analysis: Calculated for C$_{76}$H$_{116}$N$_4$O$_8$: C, 75.21; H, 9.63; N, 4.62. Found: C, 74.85; H, 9.79; N, 4.73.

Tetrabenzoxazine 11: Following the general procedure using resorcin[4]arene 4 (2 mmol, 1 equiv.) and butylamine (10 mmol, 1.25 equiv.) to afford tetrabenzoxazine 11 (1.56 mmol, 78% yield) as a red solid. $^1$H-NMR (400 MHz, CDCl$_3$): $\delta = 0.89$ (m, 24 H), 1.13 – 1.57 (m, 88 H), 2.15 (m, 8 H), 2.60 (m, 8 H), 3.76 (d, $J = 17.1$ Hz, 4 H), 3.95 (d, $J = 17.1$ Hz, 4 H), 4.20 (t, $J = 8.0$ Hz, 4 H), 4.90 (q, $J = 9.3$ Hz, 8 H), 7.08 (s, 4 H), 7.78 (s, 4 H). $^{13}$C-NMR (100 MHz, CDCl$_3$): $\delta =$ 14.1, 14.3, 20.5, 22.9, 28.3, 29.5, 29.6, 29.8, 29.9, 30.3, 32.1, 32.2, 32.8, 33.7, 33.8, 46.4, 51.2, 83.9, 108.5, 121.1, 123.5, 124.3, 148.0, 149.7. Elemental analysis: Calculated for C$_{96}$H$_{156}$N$_4$O$_8$·H$_2$O: C, 76.24; H, 10.53; N, 3.70. Found: C, 76.55; H, 9.85; N, 3.31.

Into a solution of the tetrabenzoazaine 5-11 (1.5 mmols) in isopropanol (40 ml), concentrated HX (9 ml) and water (20 ml) were added. The mixture was refluxed for 4 hours. The crude product was triturated with diethyl ether, the solid was filtered off and dried to give the desired ammonium resorcin[4]arene halide salts 12-19.


Ammonium Resorcin[4]arene Halide 12:
Following the general procedure using tetrabenzoazine 5 (1.5 mmol) and hydrobromic acid (9 mL) to afford the ammonium resorcin[4]arene bromide 12 (1.38 mmol, 92% yield) as a pale yellow solid. $^1$H-NMR (400 MHz, CDCl$_3$): $\delta$ = 0.99 (m, 24 H), 1.26 – 1.50 (m, 16 H), 1.98 (m, 8 H), 2.21 (m, 8 H), 3.19 (m, 8 H), 4.21 (m, 8), 4.37 (t, J = 7.8 Hz, 4 H), 7.26 (s, 4 H), 7.48 (br, 8 H), 8.95 (s, 8 H). $^{13}$C-NMR (100 MHz, CDCl$_3$): $\delta$ = 13.6, 14.1, 20.2, 21.2, 27.6, 33.9, 34.9, 43.9, 49.5, 108.1, 125.4, 126.1, 150.2. Elemental analysis: Calculated for C$_{60}$H$_{96}$Br$_4$N$_4$O$_8$·H$_2$O: C, 53.82 H, 7.38; N, 4.18; O, 10.75; Br, 23.87. Found: C, 54.11; H, 7.50; N, 3.95; O, 9.61; Br, 21.86. Melting point: 237 °C.
Ammonium Resorcin[4]arene Halide 13:
Following the general procedure using tetrabenzoazine 6 (1.5 mmol) and hydrobromic acid (9 mL) to afford the ammonium resorcin[4]arene bromide 14 (1.23 mmol, 82% yield) as a pale yellow solid. \(^1\)H-NMR (400 MHz, CDCl\(_3\)): \(\delta = 0.91 (t, J = 7.8 \text{ Hz, 12 H}), 0.99 (t, J = 7.8 \text{ Hz, 12 H}), 1.21 – 1.48 (m, 16 H), 2.0 (m, 8 H), 2.18 (m, 8 H), 3.12 (m, 8 H), 4.18 (m, 8), 4.32 (t, J = 7.8 Hz, 4 H), 7.22 (s, 4 H), 7.46 (br, 8 H), 8.90 (s, 8 H).

\(^{13}\)C-NMR (100 MHz, CDCl\(_3\)): \(\delta = 11.2, 14.2, 19.4, 22.7, 30.3, 32.5, 34.4, 43.7, 51.1, 108.3, 125.2, 126.1, 150.3\). **Elemental analysis**: Calculated for C\(_{60}\)H\(_{96}\)Br\(_4\)N\(_4\)O\(_8\)·H\(_2\)O: C, 53.82; H, 7.38; N, 4.18; O, 10.75; Br, 23.87. Found: C, 53.68; H, 7.41; N, 4.07; O, 10.14; Br, 22.73. **Melting point**: 260 °C.

Ammonium Resorcin[4]arene Halide 14:
Following the general procedure using tetrabenzoazine 7 (1.5 mmol) and hydrobromic acid (9 mL) to afford the ammonium resorcin[4]arene bromide 14 (1.31 mmol, 87% yield) as a pinkish yellow solid. \(^1\)H-NMR (400 MHz, CDCl\(_3\)): \(\delta = 0.92 (m, 24 H), 1.15 – 1.52 (m, 24 H), 1.96 (m, 8 H), 2.19 (m, 8 H), 3.15 (m, 8 H), 4.18 (m, 8), 4.31 (t, J = 7.9 Hz, 4 H), 7.22 (s, 4 H), 7.44 (br, 8 H), 8.91 (s, 8 H).

\(^{13}\)C-NMR (100 MHz, CDCl\(_3\)): \(\delta = 13.6, 14.2, 20.1, 22.8, 27.6, 30.3, 32.5, 34.3, 43.9, 49.5, 108.2, 125.3, 126.2, 150.3\). **Elemental analysis**: Calculated for C\(_{64}\)H\(_{104}\)Br\(_4\)N\(_4\)O\(_8\): C, 55.10; H, 7.66; N, 4.02; O, 10.32; Br, 22.91. Found: C, 54.77; H, 7.27; N, 3.78; O, 9.09; Br, 22.34. **Melting point**: 241 °C.
Ammonium Resorcin[4]arene Halide 15: Following the general procedure using tetrabenzoxazine 8 (1.5 mmol) and hydrobromic acid (9 mL) to afford the ammonium resorcin[4]arene bromide 15 (1.16 mmol, 77% yield) as a yellow solid. 

$^1$H-NMR (400 MHz, CDCl₃): \( \delta = 0.89 \, (m, 24 \, H), 1.2 - 1.48 \, (m, 40 \, H), 1.95 \, (m, 8 \, H), 2.19 \, (m, 8 \, H), 3.14 \, (m, 8 \, H), 4.17 \, (m, 8 \, H), 4.32 \, (t, J = 7.8 \, Hz, 4 \, H), 7.22 \, (s, 4 \, H), 7.45 \, (br, 8 \, H), 8.90 \, (s, 8 \, H) \)

$^{13}$C-NMR (100 MHz, CDCl₃): \( \delta = 14.1, 14.3, 22.5, 22.8, 25.7, 26.5, 30.4, 31.2, 32.6, 34.3, 43.9, 49.8, 108.2, 125.3, 126.2, 150.1 \)

Elemental analysis: Calculated for C₂₇H₁₂₅Br₄N₄O₈·2H₂O: C, 56.69; H, 8.19; N, 3.67; O, 10.49; Br, 20.95. Found: C, 56.88; H, 8.19; N, 3.63; O, 9.37; Br, 20.19. Melting point: 248 °C.

Ammonium Resorcin[4]arene Halide 16: Following the general procedure using tetrabenzoxazine 9 (1.5 mmol) and hydrobromic acid (9 mL) to afford the ammonium resorcin[4]arene bromide 16 (1.01 mmol, 67% yield) as a pale pink solid. 

$^1$H-NMR (400 MHz, CDCl₃): \( \delta = 0.86 \, (t, J = 7.3 \, Hz, 12 \, H), 1.13 - 1.43 \, (m, 16 \, H), 2.12 \, (m, 8 \, H), 4.03 \, (m, 8 \, H), 4.24 \, (t, J = 7.9 \, Hz, 4 \, H), 4.42 \, (br, 8 \, H), 7.16 \, (s, 4 \, H), 7.4 \, (m, 8 \, H), 7.70 \, (m, 8 \, H), 8.87 \, (s, 8 \, H) \)

$^{13}$C-NMR (100 MHz, CDCl₃): \( \delta = 14.2, 22.7, 30.3, 32.6, 34.2, 42.5, 52.1, 108.0, 125.1, 126.2, 129.1, 129.4, 129.9, 130.0, 130.9, 150.1 \)

Elemental analysis: Calculated for C₇₆H₇₆Br₄N₄O₈: C, 60.32; H, 6.39; N, 3.70; O, 8.47; Br, 21.12. Found: C, 57.83; H, 6.03; N, 3.46; O, 8.23; Br, 20.92. Melting point: 209 °C.
Ammonium Resorcin[4]arene Halide 17: Following the general procedure using tetrabenzoxazine 9 (1.5 mmol) and hydrochloric acid (9 mL) to afford the ammonium resorcin[4]arene chloride 17 (1.07 mmol, 71% yield) as a pale pink solid. ¹H-NMR (400 MHz, CDCl₃): δ = 0.86 (t, J = 7.3 Hz, 12 H), 1.14 – 1.42 (m, 16 H), 2.10 (m, 8 H), 4.05 (m, 8), 4.24 (t, J = 7.8 Hz, 4 H), 4.3 (br, 4 H), 7.12 (s, 4 H), 7.40 (m, 8 H), 7.7 (m, 8 H), 8.18 (br, 8 H), 8.9 (s, 8 H). ¹³C-NMR (100 MHz, CDCl₃): δ = 14.2, 22.8, 30.2, 32.7, 34.4, 42.2, 52.0, 108.8, 124.8, 126.6, 129.3, 129.7, 129.8, 130.7, 150.4. Elemental analysis: Calculated for C₇₆H₉₆Cl₄N₄O₈·2H₂O: C, 66.56; H, 7.35; N, 4.09; O, 11.67; Cl, 10.34. Found: C, 66.25; H, 7.66; N, 4.38; O, 9.04; Cl, 10.14. Melting point: 228 °C.

Ammonium Resorcin[4]arene Halide 18: Following the general procedure using tetrabenzoxazine 10 (1.5 mmol) and hydrobromic acid (9 mL) to afford the ammonium resorcin[4]arene bromide 18 (1.17 mmol, 78% yield) as a pale yellow solid. ¹H-NMR (400 MHz, CDCl₃): δ = 0.88 (t, J = 6.9 Hz, 12 H), 0.94 (t, J = 7.4 Hz, 12 H), 1.10 – 1.50 (m, 40 H), 1.95 (m, 8 H), 2.18 (m, 8 H), 3.16 (m, 8 H), 4.17 (m, 8), 4.32 (t, J = 7.8 Hz, 4 H), 7.20 (s, 4 H), 7.45 (br, 8 H), 8.90 (s, 8 H). ¹³C-NMR (100 MHz, CDCl₃): δ = 13.7, 14.2, 20.1, 22.8, 27.6, 28.1, 29.5, 32.0, 32.9, 34.4, 43.9, 49.5, 108.2, 125.3, 126.2, 150.1. Elemental analysis: Calculated for C₇₂H₁₂₀Br₄N₄O₈·H₂O: C, 57.37; H, 8.16; N, 3.72; O, 9.55; Br, 21.20. Found: C, 57.22; H, 8.50; N, 3.53; O, 9.66; Br, 20.58. Melting point: 223 °C.
Ammonium Resorcin[4]arene Halide 19:
Following the general procedure using tetrabenzoazine 11 (1.5 mmol) and hydrobromic acid (9 mL) to afford the ammonium resorcin[4]arene bromide 19 (1.11 mmol, 74% yield) as a red solid. \(^1\)H-NMR (400 MHz, CDCl₃): \(\delta = 0.91 \text{ (m, 24 H)}, 1.15 \text{ -- 1.45 (m, 80 H)}, 1.95 \text{ (m, 8 H)}, 2.18 \text{ (m, 8 H)}, 3.14 \text{ (m, 8 H)}, 4.17 \text{ (m, 8)}, 4.32 \text{ (t, J = 7.8 Hz, 4 H)}, 7.22 \text{ (s, 4 H)}, 7.46 \text{ (br, 8 H)}, 8.94 \text{ (s, 8 H)}. \(^{13}\)C-NMR (100 MHz, CDCl₃): \(\delta = 13.7, 14.3, 20.1, 22.9, 27.6, 28.2, 29.6, 29.7, 29.8, 29.9, 30.0, 30.2, 32.1, 32.9, 34.4, 43.9, 49.5, 108.1, 125.4, 126.2, 150.2.\) **Elemental analysis:** Calculated for C\(_{92}\)H\(_{160}\)Br\(_4\)N\(_4\)O\(_8\): C, 62.43; H, 9.11; N, 3.17; O, 7.23; Br, 18.06. Found: C, 63.01; H, 9.78; N, 2.86; O, 7.08; Br, 16.23. **Melting point:** 210 °C.

a) In an oven-dried 250 mL round-bottom flask, Merrifield resin (1.0 g, $f = 1.09 \text{ mmol/g}$) was added as solid. DMF (50 mL) was added and gently shaked under argon atmosphere for 30 min at room temperature. In a separate oven-dried flask, NaH (60%, 10 mmol) and tetrabenzoazine 7 (2 mmol) were added as solid. THF (50 mL) was added and this solution was stirred for 30 min at room temperature. Afterwards, the tetrabenzoazine solution was added over the Merrifield resin suspension and the reaction mixture was heated up to 70 °C under argon atmosphere using a continuous shaking for 96 hours. The reaction mixture was then filtered and the resin was washed with water, water/MeOH (1:1), MeOH, MeOH/THF (1:1) and THF (50 mL each). The solid was dried under reduced pressure at 40 °C for 24 hours to obtain the desired PS-supported tetrabenzoazine 21 ($f_N = 0.26 \text{ mmol/g}, f_{\text{max}} = 0.50 \text{ mmol/g}, 52\% \text{ yield}$).

![Diagram](image.png)

**Elemental analysis (%)**: N, 1.48; C, 86.13; H, 7.88; O, 4.35. $f_N = 0.26 \text{ mmol/g}, f_{\text{max}} = 0.50 \text{ mmol/g}$. **IR (cm$^{-1}$)**: 538, 696, 755, 905, 1028, 1068, 1111, 1181, 1223, 1375, 1451, 1492, 1601, 2857, 2923, 3003, 3025, 3059, 3083.

b) PS-supported tetrabenzoazine 21 (0.145 mmol, 1.0 equiv., $f_N = 0.26 \text{ mmol/g}$) was placed into a pressure tube. Methyl iodide (0.725 mmol, 5.0 equiv.) as solution in acetonitrile (2.5 mL) was added and the reaction mixture was heated to 75 °C, continuously shaked for 48 hours. The reaction mixture was filtered off, and the resin was washed with water, water/MeOH (1:1), MeOH, MeOH/THF (1:1) and THF (50 mL each). The solid was dried under reduced pressure at 40 °C for 24 hours to obtain the desired PS-supported resorcin[4]arene iodide salt 22 ($f_N = 0.23 \text{ mmol/g}, f_{\text{max}} = 0.25 \text{ mmol/g}, 92\% \text{ yield}$).
Elemental analysis (%): N, 1.26; C, 76.58; H, 7.04; O, 3.70; I, 12.28. $f_N = 0.23$ mmol/g ($f_{max}$ = 0.25 mmol/g). IR (cm$^{-1}$): 696, 754, 1131, 1217, 1375, 1451, 1492, 1601, 2871, 2921, 3024, 3059, 3082, 3408.

7. Synthesis and Characterization of N-Benzyl-$n$-butylammonium bromide 20

In a 10 mL vial, a suspension of N-Benzyl-$n$-butylamine (100 mg, 0.613 mmol) in diethylether (2.4 mL) was prepared. Then, hydrobromic acid (48%, 73 µL, 0.643 mmol) was added and the reaction was stirred for 1 hour observing the solution of the starting material. Afterwards, the solvent was removed under reduced pressure and the obtained orangish solid was washed with pentane to render the desired N-Benzyl-$N$-butylammonium bromide 20 as a white solid (138.0 mg, 0.564 mmol, 92% yield).

$^1$H-NMR (500 MHz, CDCl$_3$): δ = 0.89 (t, J = 7.4 Hz, 3 H), 1.36 (h, J = 7.4 Hz, 2 H), 1.86 (p, J = 7.9 Hz, 2 H), 2.75 – 2.85 (m, 2 H), 4.08 (t, J = 5.3 Hz, 2 H), 7.34 – 7.48 (m, 3 H), 7.59 – 7.65 (m, 2 H), 9.34 (br, 2 H). $^{13}$C-NMR (125 MHz, CDCl$_3$): δ = 13.6, 20.2, 27.8, 45.8, 50.6, 129.4, 129.7, 129.8, 130.7. IR (cm$^{-1}$): 509, 596, 696, 746, 1010, 1214, 1431, 1462, 1501, 2414, 2574, 2799, 2936. Melting point: 220 °C.
8. Recycling Studies

Table S1. Background reactions

<table>
<thead>
<tr>
<th>Entry</th>
<th>Catalyst</th>
<th>COC1 Yield (%)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Merrifield resin (PS-Cl)</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>Iodomethane</td>
<td>13</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>25</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>&gt;99</td>
</tr>
</tbody>
</table>

Reaction conditions: 1,2-epoxyhexane S1 (8.3 mmol), CO\(_2\) (0.5 MPa), catalyst (1 mol%), time = 18 h, temperature = 80 °C. Selectivity in all cases is >99%. *NMR Yields based on mesitylene as internal standard.

Table S2. Elemental analysis for the recycled catalyst 22.

<table>
<thead>
<tr>
<th></th>
<th>C (%)</th>
<th>H (%)</th>
<th>N (%)</th>
<th>O (%)</th>
<th>I (%)</th>
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<tbody>
<tr>
<td>Fresh</td>
<td>76.58</td>
<td>7.04</td>
<td>1.26</td>
<td>3.70</td>
<td>12.28</td>
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<tr>
<td>After 12th run</td>
<td>82.74</td>
<td>7.74</td>
<td>0.91</td>
<td>4.25</td>
<td>3.86</td>
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</table>

Table S3. Data points relating to Fig. 2.

<table>
<thead>
<tr>
<th>Run nº</th>
<th>Catalyst loading (%)</th>
<th>COC1 Yield (%)*</th>
</tr>
</thead>
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<tr>
<td>1</td>
<td>0.89</td>
<td>100</td>
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<td>2</td>
<td>n.d.</td>
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</tr>
<tr>
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<tr>
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<td>0.80</td>
<td>100</td>
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<tr>
<td>5</td>
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<tr>
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<tr>
<td>7</td>
<td>n.d.</td>
<td>91</td>
</tr>
<tr>
<td>8</td>
<td>n.d.</td>
<td>92</td>
</tr>
<tr>
<td>9</td>
<td>0.69</td>
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<tr>
<td>10</td>
<td>n.d.</td>
<td>85</td>
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<tr>
<td>11</td>
<td>n.d.</td>
<td>84</td>
</tr>
<tr>
<td>12</td>
<td>n.d.</td>
<td>85</td>
</tr>
</tbody>
</table>

Reaction conditions: 1,2-epoxyhexane S1 (8.3 mmol), CO\(_2\) (0.5 MPa), catalyst 14 (1 mol%), time = 18 h, temperature = 80 °C. Selectivity in all cases is >99%. *NMR Yields based on mesitylene as internal standard.
9. Copies of IR, $^1$H-NMR and $^{13}$C-NMR Spectra

9.1. COC1

$^1$H-NMR spectrum

COC1 ($^1$H-NMR)

$^{13}$C-NMR spectrum

COC1 ($^{13}$C-NMR)
9.2. COC2

$^1$H-NMR spectrum

COC2

$^{13}$C-NMR spectrum

COC2
9.3. COC3

$^1$H-NMR spectrum

$^{13}$C-NMR spectrum
9.4. COC4

$^1$H-NMR spectrum

COC4 (1H-NMR)

$^{13}$C-NMR spectrum

COC4 (13C-NMR)
9.5. COC5

$^1$H-NMR spectrum

COC5 ($^1$H-NMR)

$^{13}$C-NMR spectrum

COC5 ($^{13}$C-NMR)
9.6. COC6

$^1$H-NMR spectrum

COC6 [1H-NMR]

$^{13}$C-NMR spectrum

COC6 [13C-NMR]
9.7. COC7

$^1$H-NMR spectrum

\[
\text{COC7 (H-NMR)}
\]

\[
\text{Hex}
\]

\[
\text{COC7}
\]

$^{13}$C-NMR spectrum

\[
\text{COC7 (13C-NMR)}
\]

\[
\text{Hex}
\]

\[
\text{COC7}
\]
9.8. COC8

$^1$H-NMR spectrum

COC8 (1H-NMR)

$^{13}$C-NMR spectrum

COC8 ($^{13}$C-NMR)
9.9. COC9

$^1$H-NMR spectrum

COC9 ($^1$H-NMR)

13C-NMR spectrum

COC9 (13C-NMR)
9.10. COC10

$^1$H-NMR spectrum

COC10 ($^1$H-NMR)

$^{13}$C-NMR spectrum

COC10 ($^{13}$C-NMR)
9.11. COC11

$^1$H-NMR spectrum

COC11 (H-NMR)

$^{13}$C-NMR spectrum

COC11 (C-NMR)
9.12. COC12

$^1$H-NMR spectrum

COC12 (D2O-NMR)

$^{13}$C-NMR spectrum

COC12 (D2O-NMR)

$^1$H-NMR spectrum

Resorcinarene 1 (1H-NMR)

$^{13}$C-NMR spectrum

Resorcinarene 1 (13C-NMR)

$^1$H-NMR spectrum

Resorcinarene 2 (1H-NMR)

$^{13}$C-NMR spectrum

Resorcinarene 2 (13C-NMR)

$^1$H-NMR spectrum

Resorcinarene 3 (H-NMR)

$^{13}$C-NMR spectrum

Resorcinarene 3 ($^{13}$C-NMR)

$^1$H-NMR spectrum

![Resorcinarene 4 (1H-NMR)](image)

$^{13}$C-NMR spectrum

![Resorcinarene 4 (13C-NMR)](image)
9.17. Tetrabenzoazine 5

$^1$H-NMR spectrum

$^{13}$C-NMR spectrum
9.18. Tetrabenzoazine 6

$^1$H-NMR spectrum

$^{13}$C-NMR spectrum
9.19. Tetrabenzoazine 7

$^1$H-NMR spectrum

$^1$H-NMR spectrum

$^{13}$C-NMR spectrum

$^{13}$C-NMR spectrum
9.20. Tetrabenzoazine 8

$^1$H-NMR spectrum

$^{13}$C-NMR spectrum
9.21. Tetrabenzoazine 9

$^1$H-NMR spectrum

$^{13}$C-NMR spectrum
9.22. Tetrabenzoazine 10

$^1$H-NMR spectrum

$^{13}$C-NMR spectrum
9.23. Tetrabenzoazine 11

$^1$H-NMR spectrum

$^{13}$C-NMR spectrum

$^1$H-NMR spectrum

$^{13}$C-NMR spectrum

$^1$H-NMR spectrum

$^{13}$C-NMR spectrum

$^1\text{H}$-NMR spectrum

$^{13}\text{C}$-NMR spectrum

$^1$H-NMR spectrum

$^{13}$C-NMR spectrum

$^1$H-NMR spectrum

$^{13}$C-NMR spectrum

$^1$H-NMR spectrum

$^{13}$C-NMR spectrum

$^1$H-NMR spectrum

13C-NMR spectrum

$^1$H-NMR spectrum

$^{13}$C-NMR spectrum
9.32. N-Benzyl-n-butylammonium bromide 20

$^1$H-NMR spectrum

$^{13}$C-NMR spectrum
IR spectrum

![IR spectrum graph with molecular structure and wavenumber cm⁻¹ range from 3600 to 400]
**9.33. PS-supported Tetrabenzoaxazine 21**

IR spectrum
9.34. PS-supported Resorcin[4]arene Halide 22

IR spectrum

![IR spectrum](image)

22

10. References

