Electronic Supplementary Information For:

**Efficient conversion of CO\(_2\) into cyclic carbonates at room temperature catalyzed by Al-salen and imidazolium hydrogen carbonate ionic liquid**

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1. **Experimental method**

1.1 **Materials and characterization methods**

Analytical-grade salicylaldehyde, ethylenediamine, (1R,2R)-diaminocyclohexene, O-phenylenediamine, 2,3-naphthalenediamine, potassium bicarbonate, 1,3-bis(2,4,6-trimethylphenyl)imidazolium Chloride and potassium bis(trimethylsilyl)amide were purchased from Aladdin Reagent Corporation. 1-ethyl-3-methylimidazolium bromide ([C\(_1\)C\(_2\)Im][Br]), 1-buty-3-methylimidazolium bromide ([C\(_1\)C\(_4\)Im][Br]), 1-hexyl-3-methylimidazolium bromide ([C\(_1\)C\(_6\)Im][Br]), 1-ethyl-2,3-dimethylimidazolium bromide ([C\(_1\)C\(_2\)ImCH\(_3\)][Br]) were purchased from Adamas-beta company. All solvents were dried by distilled. CO\(_2\) (99.99%) was used as received without further purification. The NMR spectra were recorded by using Bruker AC-400 MHz spectrometers. High-resolution mass spectra were acquired with 6540 Q-TOF LC/MS. The reaction solution was analyzed by using a GC2014C gas chromatograph fitted with a RTX-5 column (30 m × 0.32 mm × 0.25 μm) and a flame ionization detector (FID).

1.2 **General procedure for the synthesis of salen ligands**

The anhydrous ethanol solution (20 mL) of corresponding diamine (10 mmol) was added dropwise into the solution of salicylaldehyde (20 mmol) in anhydrous ethanol at room temperature. The resulting mixture was heated to reflux overnight. The resulting residue was filtered and washed with cold ethanol (20 ml × 3), then dried under vacuum to afford the desired products.

1.3 **General procedure for the synthesis of SH\(_n\)-Al(Cl) compounds**

Under nitrogen protection and constant stirring at room temperature, to a 50 mL Schlenk flask containing the corresponding salen ligand SH\(_n\) (3 mmol), anhydrous dichloromethane (20 mL) was added via a hypodermic syringe to dissolve the ligand, then 3.5 mL of Et\(_2\)AlCl (1.0 M solution in toluene, 3.5 mmol) was added slowly. The
resulting mixture was refluxed for another 4 h. The solvent was removed under vacuum, and the residue was washed with anhydrous ether (10 ml × 3) and dried under vacuum to obtain the products.

1.4 General procedure for the synthesis of SHₙ-Al(CH₃) compounds

Under nitrogen protection and constant stirring at room temperature, to a 50 mL Schlenk flask containing the corresponding salen ligand SHₙ (3 mmol), anhydrous dichloromethane (20 mL) was added via a hypodermic syringe to dissolve the ligand, then 3.5 mL of AlMe₃ (1.0 M solution in hexane, 3.5 mmol) was added slowly. The resulting mixture was refluxed for another 4 h. The solvent was removed under vacuum, and the residue was washed with anhydrous hexane (10 ml × 3) and dried under vacuum to obtain the products.

1.5 Synthesis of imidazolium hydrogen carbonate ionic liquids

Imidazolium hydrogen carbonate ionic liquids were synthesized using the same procedure reported in our pervious papers.¹³ᵃ

1.6 Synthesis of IMes-CO₂

An 50 mL Schlenk flask was charged with 1,3-bis(2,4,6-trimethylphenyl) imidazolium Chloride (3 mmol) and potassium bis(trimethylsilyl)amide (3.1 mmol). The reactor was purged by vacuum/dry nitrogen cycles for three times. Then, dry THF (20 mL) was added and the mixture was stirred at -30°C for 2 hours. It was then allowed to stand for 2 hours. After that, dry CO₂ was bubbled into the obtained solution. After 4 hours, the solvent was evaporated under vaccum and the residue was washed with dry THF (5×10 mL). After dry under vaccum, IMes-CO₂ was obtained as white powder.

1.7 Catalytic reactions

The cycloaddition reaction were conducted in a 25 mL stainless autoclave (YZPR-25, YAN ZHENG INSTRUMENT). The catalyst (0.05 mmol), cocatalyst (0.05 mmol) and substrates (20 mmol) were charged into the stainless autoclave equipped with magnetic stirring and heating devices. The reactor was purged with CO₂ for three times and then charged with CO₂. Next, the stainless autoclave was heated to desirable temperature and stirred for 10 h (or 24h). After the reaction is completed, the remaining CO₂ is slowly discharged from the reactor. The pressure of CO₂ was controlled by a pressure reducing valve connected to the steel cylinder. The reaction solution was analyzed by using GC. The cyclic carbonates were purified by flash chromatography for NMR characterization.

The reactions that need to be performed at atmospheric pressure use Schlenk flask and CO₂ ballon rather than stainless autoclave.

1.8 Procedure for the recycle of catalytic system

After the catalytic reaction was completed and the remaining CO₂ was discharged from the reactor, the final mixture was added diethyl ether (30 mL). Styrene oxide and
styrene carbonate are soluble in diethyl ether, while the catalyst and cocatalyst are insoluble in diethyl ether. The mixture of catalyst and cocatalyst were separated by centrifugation. The mixture of catalyst and cocatalyst were washed by diethyl ether (3×5ml). The recovered catalyst and cocatalyst was dried 10 h under vacuum and reused for the next running of catalytic reaction.

2.1 The chemical shift of Al-Me in SH4-Al(CH3) in the 1H NMR spectrum

Fig. S1. 1H NMR spectra of a mixture of SH4-Al(CH3) and propylene carbonate in dual NMR cell. The CDCl3 was placed in the inner cell, whereas samples were placed in the outer cell.
Fig. S2. $^1$H NMR spectra of a mixture of SH$_4$-Al(CH$_3$), propylene carbonate and propylene epoxide in dual NMR cell. The CDCl$_3$ was placed in the inner cell, whereas samples were placed in the outer cell.

2.2 The separation efficiency of SH$_4$-Al(Cl) and [C$_1$C$_6$Im][HCO$_3$] in recovery operation

Fig. S3. $^1$H NMR spectra of styrene carbonate extracted by diethyl ether. No observable signal of SH$_4$-Al(Cl) and [C$_1$C$_6$Im][HCO$_3$] were detected in styrene carbonate (diethyl ether extraction phase).

Fig. S4. (a) The photo of catalyst recovery operation; (b) UV absorption spectra of SH$_4$-Al(Cl) in methanol; (c) The standard curve obtained by measuring the
absorbance of SH-Al(Cl) with different concentrations at 384 nm. The residual catalyst in the extraction phase was determined to be 0.318 mg by UV and the recovery rate of SH-Al(Cl) was 98.5%.

### 2.3 $^{13}$C labeling experiments

Fig. S5. $^{13}$C NMR of $^{13}$C-labeled $[\text{C}_1\text{C}_6\text{Im}][\text{H}^{13}\text{CO}_3]$ in D$_2$O. Reaction conditions: SH-Al(Cl) 0.25mol%, $[\text{C}_1\text{C}_6\text{Im}][\text{HCO}_3]$ 5mol%, styrene oxide 10mmol, 25°C, CO$_2$ pressure 1.0MPa, 20h.
Fig. S6. MS spectrum of propylene carbonate synthesized by the reaction between [IMes][H^{13}CO_3] and propylene epoxide. Reaction conditions: SH4-Al(Cl) 0.05mmol, [IMes][H^{13}CO_3] 0.3mmol, propylene epoxide 8.6mmol, 25°C, 36h.

2.4 Synthesis of propylene carbonate with [IMes][HCO_3] as carbon source without CO_2.

Fig. S7. ¹H NMR spectra of reaction mixture in CDCl₃. Reaction conditions: SH4-Al(Cl) 0.05mmol, [IMes][HCO_3] 0.8mmol, propylene epoxide 8.6mmol, 25°C, 36h. After reaction, propylene epoxide was removed by vacuum distillation, the
mixture was dissolved in CDCl₃, then 0.57mmol (0.072g) n-hexane was added as the internal standard. By calculating the area of methyl peak of PC and n-hexane, the yield of PC is 0.342mmol (42.8% based on [IMes][HCO₃]).

3. Characterization results
The ¹H and ¹³C NMR spectra of SH₁
¹H-NMR (400 MHz, DMSO-d₆): δ 13.39 (2H, OH), 8.59 (2H, Ar-CH=N-), 7.43-7.41 (2H, Ar-H), 7.34-7.30 (2H, Ar-H), 6.91-6.87 (4H, Ar-H), 3.92 (4H, =NCH₂-) ¹³C-NMR (100 MHz, DMSO-d₆): δ 167.38 (Ar-CH=N-), 161.04, 132.82, 132.13, 119.06, 119.02, 116.94 (Ar), 59.24 (=NCH₂-)

![Fig. S8. ¹H NMR spectra of SH₁ in DMSO](image-url)
**Fig. S9.** $^{13}$C NMR spectra of SH$_1$ in DMSO

**The $^1$H and $^{13}$C NMR spectra of SH$_2$**

$^1$H-NMR (400 MHz, DMSO-d$_6$): $\delta$ 13.32 (2H, OH), 8.49 (2H, Ar-CH=N-), 7.35-7.25 (4H, Ar-H), 6.85-6.81 (4H, Ar-H), 3.44-3.37 (2H, =NCH-), 1.90-1.43 (8H, -CH$_2$-)

$^{13}$C-NMR (100 MHz, DMSO-d$_6$): $\delta$ 165.56 (Ar-CH=N-), 160.84, 132.70, 132.07, 119.02, 118.98, 116.81 (Ar), 71.8 (=NCH-), 33.0, 24.19 (-CH$_2$-)

**Fig. S10.** $^1$H NMR spectra of SH$_2$ in DMSO
Fig. S11. $^{13}$C NMR spectra of SH$_2$ in DMSO

The $^1$H and $^{13}$C NMR spectra of SH$_3$

$^1$H-NMR (400 MHz, DMSO-d$_6$): δ 12.96 (2H, OH), 8.94 (2H, Ar-CH=N-), 7.69-7.67 (2H, Ar-H), 7.48-7.40 (6H, Ar-H), 7.00-6.97 (4H, Ar-H)

$^{13}$C-NMR (100 MHz, DMSO-d$_6$): δ 164.50 (Ar-CH=N-), 160.87, 142.74, 133.90, 132.93, 128.26, 120.22, 119.97, 119.54, 117.15 (Ar)

Fig. S12. $^1$H NMR spectra of SH$_3$ in DMSO

Fig. S13. $^{13}$C NMR spectra of SH$_3$ in DMSO
The $^1$H and $^{13}$C NMR spectra of SH$_4$


$^{13}$C-NMR (100 MHz, DMSO-d$_6$): $\delta$ 164.63 (Ar-CH=N-), 160.93, 142.87, 134.02, 132.89, 132.85, 128.20, 126.77, 120.05, 119.64, 117.20, 117.14(Ar)

Fig. S14. $^1$H NMR spectra of SH$_4$ in DMSO
Fig. S15. $^{13}$C NMR spectra of SH$_4$ in DMSO

The $^1$H and $^{13}$C NMR spectra of SH$_1$-Al(Cl)

$^1$H-NMR (400 MHz, DMSO-d$_6$): $\delta$ 8.53 (2H, Ar-CH=N-), 7.41-7.36 (4H, Ar-H), 6.87-6.85 (2H, Ar-H), 6.75-6.71 (2H, Ar-H), 3.86 (4H, =NCH2-)

$^{13}$C-NMR (100 MHz, DMSO-d$_6$): $\delta$ 167.57 (Ar-CH=N-), 164.95, 135.51, 134.60, 121.64, 120.04, 116.40 (Ar), 53.53 (=NCH2-)

Fig. S16. $^1$H NMR spectra of SH$_1$-Al(Cl) in DMSO

Fig. S17. $^{13}$C NMR spectra of SH$_1$-Al(Cl) in DMSO
The $^1$H and $^{13}$C NMR spectra of SH$_2$-Al(Cl)

$^1$H-NMR (400 MHz, DMSO-d$_6$): $\delta$ 8.37 (2H, Ar-CH=N-), 7.53-7.51 (2H, Ar-H), 7.40-7.35 (2H, Ar-H), 6.87-6.85 (2H, Ar-H), 6.75-6.71 (2H, Ar-H), 3.37-3.36 (2H, =NCH-), 2.57-2.54 (2H, -CH$_2$-), 1.95-1.93 (2H, -CH$_2$-), 1.40-1.37 (2H, -CH$_2$-)

$^{13}$C-NMR (100 MHz, DMSO-d$_6$): $\delta$ 164.80 (Ar-CH=N-), 163.74, 135.50, 135.25, 121.53, 120.12, 116.32 (Ar), 63.64 (=NCH-), 27.38, 23.87 (-CH$_2$-)

Fig. S18. $^1$H NMR spectra of SH$_2$-Al(Cl) in DMSO
The $^1$H and $^{13}$C NMR spectra of SH3-Al(Cl)


$^{13}$C-NMR (100 MHz, DMSO-$d_6$): δ 165.94 (Ar-CH=N), 162.04, 137.94, 137.34, 136.32, 129.25, 121.91, 120.08, 117.57, 117.14 (Ar)
Fig. S21. $^{13}$C NMR spectra of SH$_3$-Al(Cl) in DMSO

The $^1$H and $^{13}$C NMR spectra of SH$_4$-Al(Cl)

$^1$H-NMR (400 MHz, DMSO-d$_6$): δ 9.54 (2H, Ar-CH=N-), 8.72 (2H, Ar-H), 8.01-7.99 (2H, Ar-H), 7.77-7.75 (2H, Ar-H), 7.63-7.60 (2H, Ar-H), 7.56-7.52 (2H, Ar-H), 7.00-6.98 (2H, Ar-H), 6.90-6.86 (2H, Ar-H)

$^{13}$C-NMR (100 MHz, DMSO-d$_6$): δ 166.26 (Ar-CH=N-), 162.89, 137.53, 136.81, 136.34, 132.84, 128.56, 127.80, 122.00, 120.28, 117.28, 115.53 (Ar)

Fig. S22. $^1$H NMR spectra of SH$_4$-Al(Cl) in DMSO

Fig. S23. $^{13}$C NMR spectra of SH$_4$-Al(Cl) in DMSO
The $^1$H and $^{13}$C NMR spectra of SH$_3$-Al(CH$_3$)

$^1$H-NMR (400 MHz, DMSO-d$_6$): $\delta$ 9.26 (2H, Ar-CH=N-), 8.07-8.05 (2H, Ar-H), 7.64-7.61 (2H, Ar-H), 7.54-7.46 (4H, Ar-H), 6.92-6.90 (2H, Ar-H), 6.84-6.80 (2H, Ar-H), -1.31(3H, Al-Me)

$^{13}$C-NMR (100 MHz, DMSO-d$_6$): $\delta$ 166.27 (Ar-CH=N-), 163.77, 138.74, 137.12, 135.44, 129.24, 121.87, 119.68, 117.71, 117.03 (Ar)

Fig. S24. $^1$H NMR spectra of SH$_3$-Al(CH$_3$) in DMSO

Fig. S25. $^{13}$C NMR spectra of SH$_3$-Al(CH$_3$) in DMSO
The $^1$H and $^{13}$C NMR spectra of SH$_4$-Al(CH$_3$)


$^{13}$C-NMR (100 MHz, DMSO-d$_6$): $\delta$ 166.56 (Ar-CH=N-$\text{-}$), 164.72, 137.81, 137.31, 135.48, 133.01, 128.52, 127.59, 121.92, 119.82, 117.15, 115.59 (Ar)

Fig. S26. $^1$H NMR spectra of SH$_4$-Al(CH$_3$) in DMSO

Fig. S27. $^{13}$C NMR spectra of SH$_4$-Al(CH$_3$) in DMSO
The $^1$H and $^{13}$C NMR spectra of [IMes][Cl]

$^1$H-NMR, (400 MHz, CD$_3$OD): $\delta$ 8.06-8.05 (1H, N-CH-N), 6.58-6.57 (2H, CH-CH), 5.70 (4H, Ar-H), 0.90 (6H, Ar-CH$_3$), 0.70 (12H, Ar-CH$_3$)

$^{13}$C-NMR, (100 MHz, CD$_3$OD): $\delta$ 140.01 (N-CH-N), 137.05 (CH-CH), 132.83, 129.46, 128.04, 123.69 (Ar), 18.37, 14.63 (Ar-CH$_3$)

Fig. S28. $^1$H NMR spectra of [IMes][Cl] in CD$_3$OD

Fig. S29. $^{13}$C NMR spectra of [IMes][Cl] in CD$_3$OD
The $^1$H and $^{13}$C NMR spectra of IMes-CO$_2$

$^1$H-NMR, (400 MHz, CD$_3$OD): $\delta$ 6.52 (2H, CH-CH), 5.66 (4H, Ar-H), 0.86 (6H, Ar-CH$_3$), 0.65 (12H, Ar-CH$_3$)

$^{13}$C-NMR, (100 MHz, CD$_3$OD): $\delta$ 158.46 (N-C-N), 140.00 (CH-CH), 132.76, 129.41, 127.97, 123.57 (Ar), 18.26, 14.51 (Ar-CH$_3$)

Fig. S30. $^1$H NMR spectra of IMes-CO$_2$ in CD$_3$OD

Fig. S31. $^{13}$C NMR spectra of IMes-CO$_2$ in CD$_3$OD
The $^1$H and $^{13}$C NMR spectra of [C$_1$C$_2$ImCH$_3$][HCO$_3$]

$^1$H-NMR, (400 MHz, DMSO-d$_6$): δ 1.36-1.33 (t, 3H, -CH$_3$), 2.66 (s, 3H, C-CH$_3$), 3.83 (s, 2H, N-CH$_3$), 4.25-4.19 (t, N-CH$_2$-), 7.79-7.78 (d, 1H, -CH=C-), 7.83 (d, 1H, -C=CH-)

$^{13}$C-NMR, (100 MHz, DMSO-d$_6$): δ 9.94 (C-CH$_3$) 15.44 (-CH$_3$), 35.27 (N-CH$_3$), 43.26 (N-CH$_2$-), 120.81 (-CH=), 122.80 (=CH-), 144.53 (N-C-N)

Fig. S32. $^1$H NMR spectra of [C$_1$C$_2$ImCH$_3$][HCO$_3$] in DMSO

Fig. S33. $^{13}$C NMR spectra of [C$_1$C$_2$ImCH$_3$][HCO$_3$] in DMSO
Fig. S34. MS spectrum of \textit{SH}_1-\textit{Al(Cl)} \textit{(m/z} \text{calcd for [C}_{16}\text{H}_{14}\text{AlN}_{2}\text{O}_{2}]^+ 293.0865, found 293.0865)

Fig. S35. MS spectrum of \textit{SH}_2-\textit{Al(Cl)} \textit{(m/z} \text{calcd for [C}_{20}\text{H}_{20}\text{AlN}_{2}\text{O}_{2}]^+ 347.1335, found 347.1332)

Fig. S36. MS spectrum of \textit{SH}_3-\textit{Al(Cl)} \textit{(m/z} \text{calcd for [C}_{20}\text{H}_{14}\text{AlN}_{2}\text{O}_{2}]^+ 341.0865, found 341.0867)
**Fig. S37.** MS spectrum of **SH$_4$-Al(Cl)** ($m/z$ calcd for [C$_{24}$H$_{16}$AlN$_2$O$_2$]$^+$ 391.1022, found 391.1022)

**Fig. S38.** MS spectrum of **SH$_3$-Al(CH$_3$)** ($m/z$ calcd for [C$_{20}$H$_{14}$AlN$_2$O$_2$]$^+$ 341.0865, found 341.0861, $m/z$ calcd for [C$_{21}$H$_{17}$AlN$_2$O$_2$ + Na]$^+$ 379.1003, found 379.0994)

**Fig. S39.** MS spectrum of **SH$_4$-Al(CH$_3$)** ($m/z$ calcd for [C$_{24}$H$_{16}$AlN$_2$O$_2$]$^+$ 391.1022, found 391.1019, $m/z$ calcd for [C$_{25}$H$_{19}$AlN$_2$O$_2$ + Na]$^+$ 429.1160, found 429.1154)
The $^1$H and $^{13}$C NMR spectra of 4-Methyl-1,3-dioxolan-2-one

$^1$H-NMR (400 MHz, CDCl$_3$): $\delta$ 4.94-4.86 (1H, O-CH-), 4.61-4.57 (1H, O-CH$_2$), 4.07-4.03 (1H, O-CH$_2$), 1.48-1.46 (3H, -CH$_3$)

$^{13}$C-NMR (100 MHz, CDCl$_3$): $\delta$ 155.13, 73.75, 70.65, 18.92

Fig. S40. $^1$H NMR spectra of 4-Methyl-1,3-dioxolan-2-one in CDCl$_3$

Fig. S41. $^{13}$C NMR spectra of 4-Methyl-1,3-dioxolan-2-one in CDCl$_3$
The $^1$H and $^{13}$C NMR spectra of 4-(Chloromethyl)-1,3-dioxolan-2-one

$^1$H-NMR (400 MHz, CDCl$_3$): δ 5.1-5.06 (1H, O-CH-), 4.65-4.61 (1H, O-CH$_2$), 4.43-4.39 (1H, O-CH$_2$), 3.90-3.87 (1H, Cl-CH$_2$), 3.78-3.76 (1H, Cl-CH$_2$)

$^{13}$C-NMR (100 MHz, CDCl$_3$): δ 154.70, 74.68, 66.99, 44.48

Fig. S42. $^1$H NMR spectra of 4-(Chloromethyl)-1,3-dioxolan-2-one in CDCl$_3$

Fig. S43. $^{13}$C NMR spectra of 4-(Chloromethyl)-1,3-dioxolan-2-one in CDCl$_3$
The $^1$H and $^{13}$C NMR spectra of 4,4-Dimethyl-1,3-dioxolan-2-one

$^1$H-NMR (400 MHz, CDCl$_3$): $\delta$ 4.19 (2H, O-CH$_2$), 1.51 (6H, -CH$_3$)

$^{13}$C-NMR (100 MHz, CDCl$_3$): $\delta$ 154.54, 81.87, 75.17, 25.57

Fig. S44. $^1$H NMR spectra of 4,4-Dimethyl-1,3-dioxolan-2-one in CDCl$_3$

Fig. S45. $^{13}$C NMR spectra of 4,4-Dimethyl-1,3-dioxolan-2-one in CDCl$_3$
The $^1$H and $^{13}$C NMR spectra of 4-(Chloromethyl)-4-methyl-1,3-dioxolan-2-one

$^1$H-NMR (400 MHz, CDCl$_3$): $\delta$ 4.53-4.50 (1H, O-CH$_2$), 4.24-4.22 (1H, O-CH$_2$), 3.79-3.68 (2H, Cl-CH$_2$), 1.62 (3H, -CH$_3$)

$^{13}$C-NMR (100 MHz, CDCl$_3$): $\delta$ 154.08, 81.96, 72.03, 48.76, 22.85

Fig. S46. $^1$H NMR spectra of 4-(Chloromethyl)-4-methyl-1,3-dioxolan-2-one in CDCl$_3$

Fig. S47. $^{13}$C NMR spectra of 4-(Chloromethyl)-4-methyl-1,3-dioxolan-2-one in CDCl$_3$
The $^1$H and $^{13}$C NMR spectra of 4-Ethyl-1,3-dioxolan-2-one

$^1$H-NMR (400 MHz, CDCl$_3$): δ 4.76-4.69 (1H, O-CH), 4.59-4.55 (1H, O-CH$_2$), 4.13-4.10 (1H, O-CH$_2$), 1.82-1.75 (2H, -CH$_2$-), 1.03-0.99 (3H, -CH$_3$)

$^{13}$C-NMR (100 MHz, CDCl$_3$): δ 155.13, 78.07, 68.96, 26.48, 8.10

Fig. S48. $^1$H NMR spectra of 4-Ethyl-1,3-dioxolan-2-one in CDCl$_3$

Fig. S49. $^{13}$C NMR spectra of 4-Ethyl-1,3-dioxolan-2-one in CDCl$_3$
The $^1$H and $^{13}$C NMR spectra of 4-Butyl-1,3-dioxolan-2-one

$^1$H-NMR (400 MHz, CDCl$_3$): δ 4.78-4.71 (1H, O-CH), 4.59-4.55 (1H, O-CH$_2$), 4.11-4.07 (1H, O-CH$_2$), 1.79-1.70 (2H, -CH$_2$), 1.41-1.37 (4H, -CH$_2$), 0.94-0.91 (3H, -CH$_3$)

$^{13}$C-NMR (100 MHz, CDCl$_3$): δ 155.09, 77.12, 69.35, 33.20, 26.26, 22.04, 13.54

Fig. S50. $^1$H NMR spectra of 4-Butyl-1,3-dioxolan-2-one in CDCl$_3$

Fig. S51. $^{13}$C NMR spectra of 4-Butyl-1,3-dioxolan-2-one in CDCl$_3$
The $^1$H and $^{13}$C NMR spectra of 4-Hexyl-1,3-dioxolan-2-one

$^1$H-NMR (400 MHz, CDCl$_3$): $\delta$ 4.73 (1H, O-CH), 4.55 (1H, O-CH$_2$), 4.09-4.07 (1H, O-CH$_2$), 1.78-1.71 (2H, -CH$_2$-), 1.49-1.28 (8H, -CH$_2$-), 0.89 (3H, -CH$_3$)

$^{13}$C-NMR (100 MHz, CDCl$_3$): $\delta$ 155.14, 77.15, 69.41, 33.67, 31.42, 28.68, 24.22, 22.34, 13.84

Fig. S52. $^1$H NMR spectra of 4-Hexyl-1,3-dioxolan-2-one in CDCl$_3$

Fig. S53. $^{13}$C NMR spectra of 4-Hexyl-1,3-dioxolan-2-one in CDCl$_3$
The $^1$H and $^{13}$C NMR spectra of 4-Phenyl-1,3-dioxolan-2-one

$^1$H-NMR (400 MHz, CDCl$_3$): $\delta$ 7.41-7.33 (5H, Ar-H), 5.68-5.64 (1H, O-CH), 4.79-4.75 (1H, O-CH$_2$), 4.32-4.28 (1H, O-CH$_2$)

$^{13}$C-NMR (100 MHz, CDCl$_3$): $\delta$ 155.02, 135.93, 129.70, 129.22, 126.01, 78.08, 71.23

Fig. S54. $^1$H NMR spectra of 4-Phenyl-1,3-dioxolan-2-one in CDCl$_3$

Fig. S55. $^{13}$C NMR spectra of 4-Phenyl-1,3-dioxolan-2-one in CDCl$_3$
The $^1$H and $^{13}$C NMR spectra of 4-(Phenoxymethyl)-1,3-dioxolan-2-one

$^1$H-NMR (400 MHz, CDCl$_3$): $\delta$ 7.95-7.91 (2H, Ar-H), 7.66-7.62 (1H, Ar-H), 7.55-7.52 (2H, Ar-H), 5.67-5.64 (1H, O-CH), 5.25-5.13 (2H, O-CH$_2$), 4.88-4.84 (1H, O-CH$_2$), 4.77-4.74 (1H, O-CH$_2$)

$^{13}$C-NMR (100 MHz, CDCl$_3$): $\delta$ 156.77, 153.75, 128.67, 120.94, 113.61, 73.21, 65.89, 65.20

Fig. S56. $^1$H NMR spectra of 4-(Phenoxymethyl)-1,3-dioxolan-2-one in CDCl$_3$

Fig. S57. $^{13}$C NMR spectra of 4-(Phenoxymethyl)-1,3-dioxolan-2-one in CDCl$_3$
The $^1$H and $^{13}$C NMR spectra of 4-((Allyloxy)methyl)-1,3-dioxolan-2-one

$^1$H-NMR (400 MHz, CDCl$_3$): δ 5.92-5.82 (1H, =CH-), 5.30-5.17 (2H, =CH$_2$), 4.91-4.86 (1H, O-CH$_2$), 4.55-4.50 (1H, O-CH$_2$), 4.38-4.34 (1H, O-CH$_2$), 4.05-4.03 (2H, O-CH$_2$), 3.73-3.69 (1H, O-CH$_2$), 3.62-3.58 (1H, O-CH$_2$)

$^{13}$C-NMR (100 MHz, CDCl$_3$): δ 155.16, 133.93, 117.10, 75.39, 72.08, 68.93, 66.13

Fig. S58. $^1$H NMR spectra of 4-((Allyloxy)methyl)-1,3-dioxolan-2-one in CDCl$_3$

Fig. S59. $^{13}$C NMR spectra of 4-((Allyloxy)methyl)-1,3-dioxolan-2-one in CDCl$_3$
The $^1$H and $^{13}$C NMR spectra of 4-((Tert-butoxy)methyl)-1,3-dioxolan-2-one

$^1$H-NMR (400 MHz, CDCl$_3$): $\delta$ 4.85-4.79 (1H, O-CH), 4.52-4.48 (1H, O-CH$_2$), 4.39-4.36 (1H, O-CH$_2$), 3.66-3.63 (1H, O-CH$_2$), 3.54-3.50 (1H, O-CH$_2$), 1.20 (9H, -CH$_3$)

$^{13}$C-NMR (100 MHz, CDCl$_3$): $\delta$ 155.30, 75.43, 73.60, 66.38, 61.22, 21.17

Fig. S60. $^1$H NMR spectra of 4-((Tert-butoxy)methyl)-1,3-dioxolan-2-one in CDCl$_3$

Fig. S61. $^{13}$C NMR spectra of 4-((Tert-butoxy)methyl)-1,3-dioxolan-2-one in CDCl$_3$
The $^1$H and $^{13}$C NMR spectra of 4-(benzyloxymethyl)-1,3-dioxolan-2-one

$^1$H-NMR (400 MHz, CDCl$_3$): $\delta$ 7.30-7.27 (5H, Ar-H), 4.75-4.74 (1H, O-CH), 4.52-4.51 (2H, Ar-CH$_2$), 4.41-4.36 (1H, O-CH$_2$), 4.30-4.26 (1H, O-CH$_2$), 3.67-3.64 (1H, O-CH$_2$), 3.54-3.52 (1H, O-CH$_2$)

$^{13}$C-NMR (100 MHz, CDCl$_3$): $\delta$ 155.26, 137.42, 128.55, 127.98, 127.70, 75.37, 73.50, 69.04, 66.29

Fig. S62. $^1$H NMR spectra of 4-(benzyloxymethyl)-1,3-dioxolan-2-one in CDCl$_3$
The $^1$H and $^{13}$C NMR spectra of 4-(But-3-en-1-yl)-1,3-dioxolan-2-one

$^1$H-NMR (400 MHz, CDCl$_3$): $\delta$ 5.81-5.79 (1H, =CH-), 5.11-5.03 (2H, =CH$_2$), 4.77-4.74 (1H, O-CH), 4.58-4.53 (1H, O-CH$_2$), 4.12-4.08 (1H, O-CH$_2$), 2.22-2.19 (2H, -CH$_2$-), 1.93-1.79 (2H, -CH$_2$-)

$^{13}$C-NMR (100 MHz, CDCl$_3$): $\delta$ 155.05, 136.25, 116.14, 76.47, 69.37, 32.91, 28.58
The $^1$H and $^{13}$C NMR spectra of Cyclohexene carbonate

$^1$H-NMR (400 MHz, CDCl$_3$): $\delta$ 4.75-4.73 (2H, O-CH), 1.92-1.86 (4H, -CH$_2$-), 1.61-1.58 (4H, -CH$_2$-), 1.47-1.44 (4H, -CH$_2$-)

$^{13}$C-NMR (100 MHz, CDCl$_3$): $\delta$ 155.37, 75.76, 26.56, 18.97

Fig. S66. $^1$H NMR spectra of Cyclohexene carbonate in CDCl$_3$

Fig. S67. $^{13}$C NMR spectra of Cyclohexene carbonate in CDCl$_3$
The $^1$H and $^{13}$C NMR spectra of 1,2-Cyclopentylene carbonate

$^1$H-NMR (400 MHz, CDCl$_3$): δ 5.15-5.13 (2H, O-CH), 2.14-2.11 (2H, -CH$_2$-), 1.82-1.72 (4H, -CH$_2$-)

$^{13}$C-NMR (100 MHz, CDCl$_3$): δ 155.53, 81.89, 33.03, 21.52

Fig. S68. $^1$H NMR spectra of 1,2-Cyclopentylene carbonate in CDCl$_3$

Fig. S69. $^{13}$C NMR spectra of 1,2-Cyclopentylene carbonate in CDCl$_3$
The $^{1}$H and $^{13}$C NMR spectra of Tetrahydrofuro[3,4-d]-1,3-dioxol-2-one

$^{1}$H-NMR (400 MHz, CDCl$_3$): $\delta$ 5.26-5.25 (2H, O-CH), 4.23-4.22 (2H, -CH$_2$-), 3.60-3.56 (2H, -CH$_2$-)

$^{13}$C-NMR (100 MHz, CDCl$_3$): $\delta$ 154.62, 80.28, 72.95

Fig. S70. $^1$H NMR spectra of Tetrahydrofuro[3,4-d]-1,3-dioxol-2-one in CDCl$_3$

Fig. S71. $^{13}$C NMR spectra of Tetrahydrofuro[3,4-d]-1,3-dioxol-2-one in CDCl$_3$