

Electronic supplementary information of

Hydration of Isocyanates in an Expandable, Self-Assembled Capsule

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Experimental

Materials and General Methods: ^1H NMR spectra were recorded on a Bruker DRX-600 spectrometer with a 5 mm QNP probe. Proton (^1H) chemical shifts, reported parts per million (ppm), were indirectly referenced to external tetramethylsilane employing resonance as an internal reference. Deuterated mesitylene was obtained from Cambridge Isotope Laboratories, Inc. All reagents were obtained from commercial supplies and used without further purification.

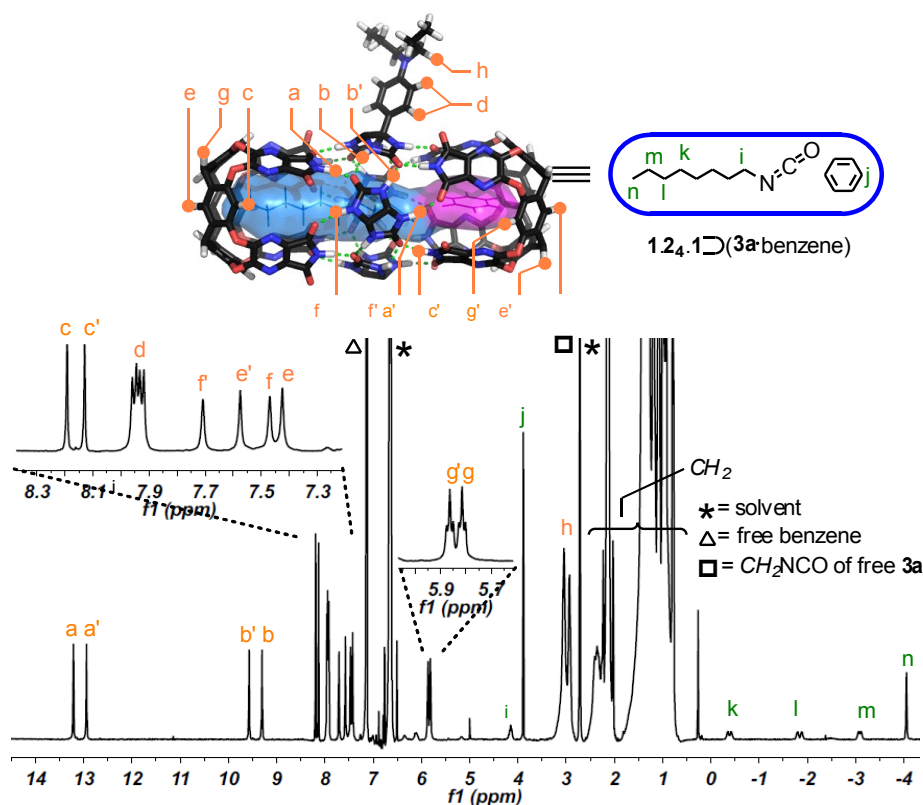


Fig. S-1 ^1H NMR spectrum (600 MHz, 300 K, mesitylene- d_{12}) of $1.2.1\text{⊃}(3a\cdot\text{benzene})$.

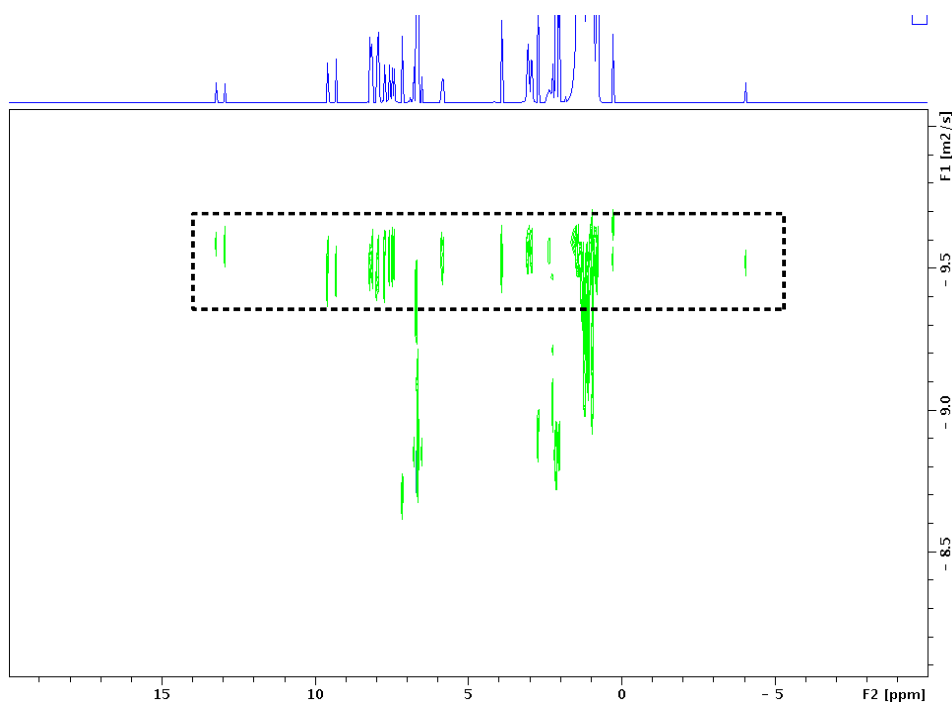


Fig. S-2 ^1H DOSY NMR spectrum (300 K, mesitylene- d_{12}) of $D_1 = 7.0$ s, 32 steps.

Table S-1. Chemical shifts and diffusion coefficients.

proton	chemical shift (ppm)	D (m^2/s)	proton	chemical shift (ppm)	D (m^2/s)
H _a	13.2	2.90×10^{-10}	H _e	7.42	3.34×10^{-10}
H _{a'}	12.9	2.98×10^{-10}	Free benzene	7.14	2.05×10^{-9}
H _b	9.58	3.27×10^{-10}	H _{g'}	5.87	3.39×10^{-10}
H _{b'}	9.31	3.32×10^{-10}	H _g	5.82	3.33×10^{-10}
H _c	8.2	3.29×10^{-10}	H _j	3.9	3.4×10^{-10}
H _{c'}	8.14	3.2×10^{-10}	H _h	3.05	3.14×10^{-10}
H _d	7.93	3.25×10^{-10}	H _h	2.93	3.28×10^{-10}
H _f	7.72	3.18×10^{-10}	NCH ₂ of free 3a	2.72	1.39×10^{-9}
H _{e'}	7.58	3.14×10^{-10}	H _n	-4.05	3.26×10^{-10}
H _f	7.48	3.15×10^{-10}			

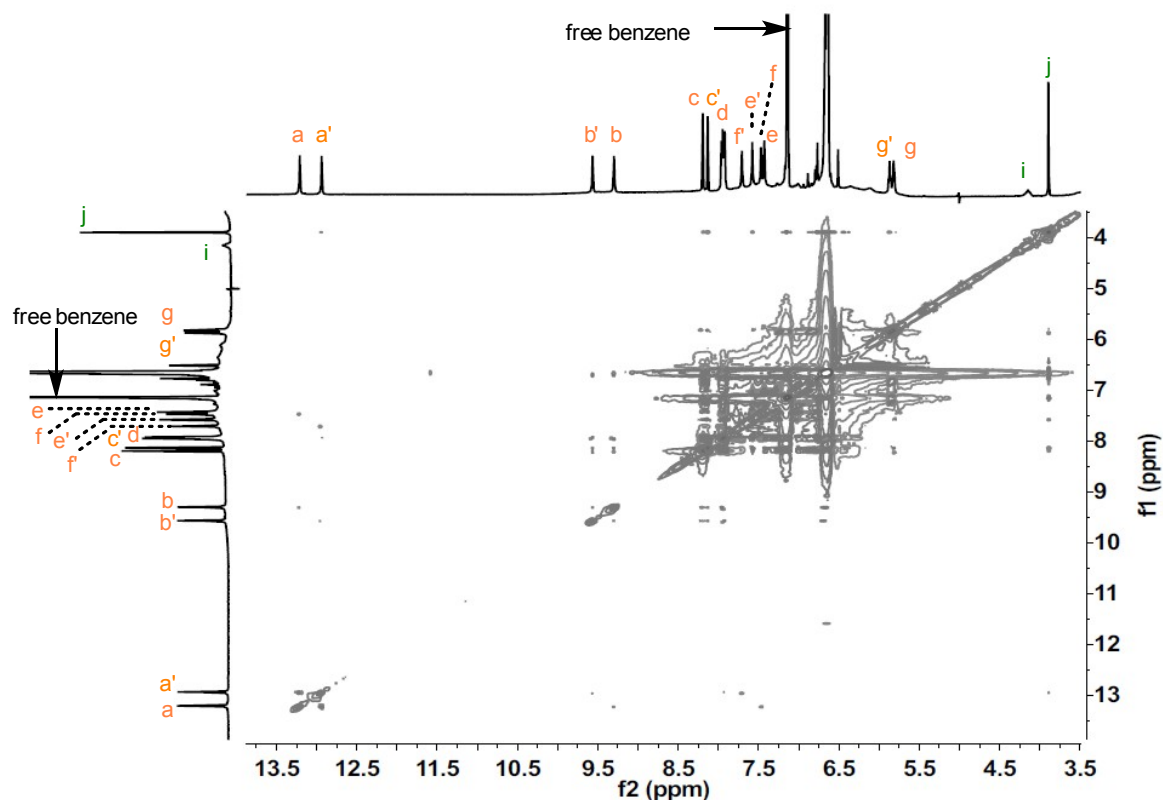


Fig. S-3 2D ROESY NMR spectra (600 MHz, 300 K, mesitylene-*d*₁₂) of **1.2.4.1**⊃(**3a**·benzene).

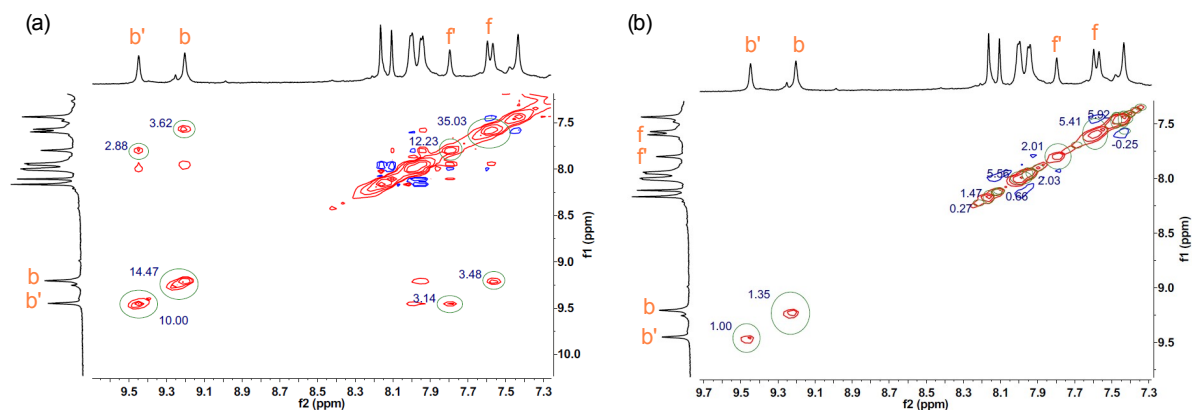


Fig. S-4 2D NOESY spectrum (600 MHz, 300 K, mesitylene-*d*₁₂) of **1.2.4.1**⊃(**3a**·benzene) showing chemical exchange between H_b (H_{b'}) and H_f (H_{f'}). (a) mixing time 400 ms, (b) mixing time 0 ms. The study of the process by 2D EXSY spectroscopy revealed k^{-1} value of 0.47 s⁻¹ corresponding to $\Delta G^\ddagger = 18.0$ kcal mol⁻¹ at 300 K.

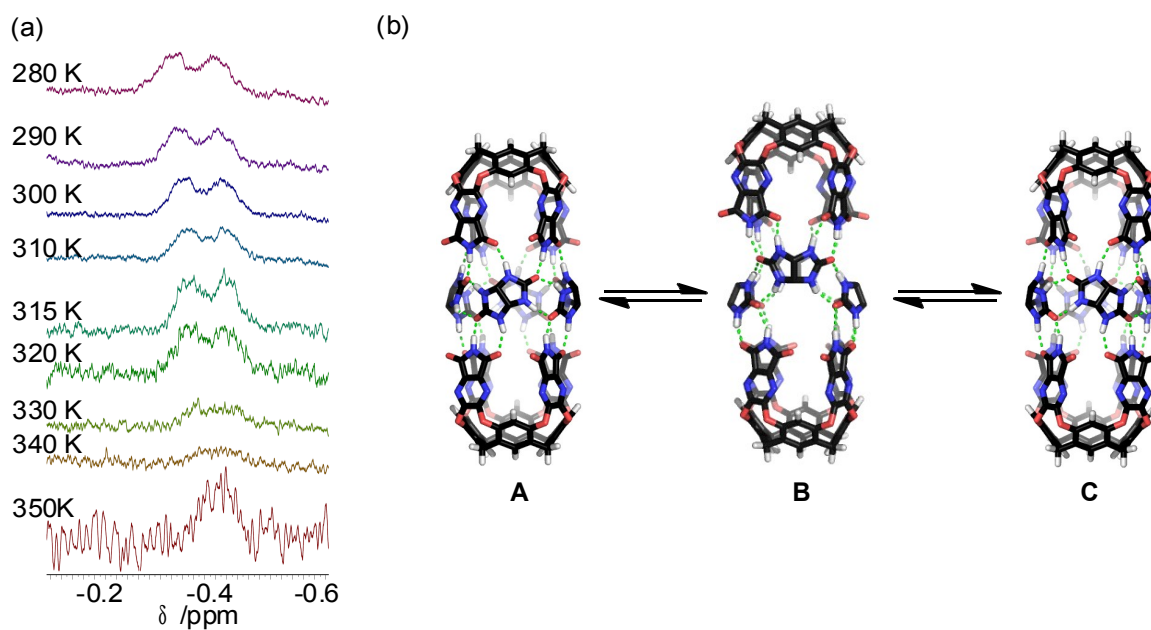


Fig. S-5 (a) V.T. NMR spectra of of **1.2.4.1**⊃(**3a**·benzene), (b) Racemization of **1.2.4.1**. The diastereotopic signal (H_f) coalesce at 330 K, giving $\Delta G^\ddagger = 17.3 \text{ kcal mol}^{-1}$ corresponding to free energy of activation for racemization.

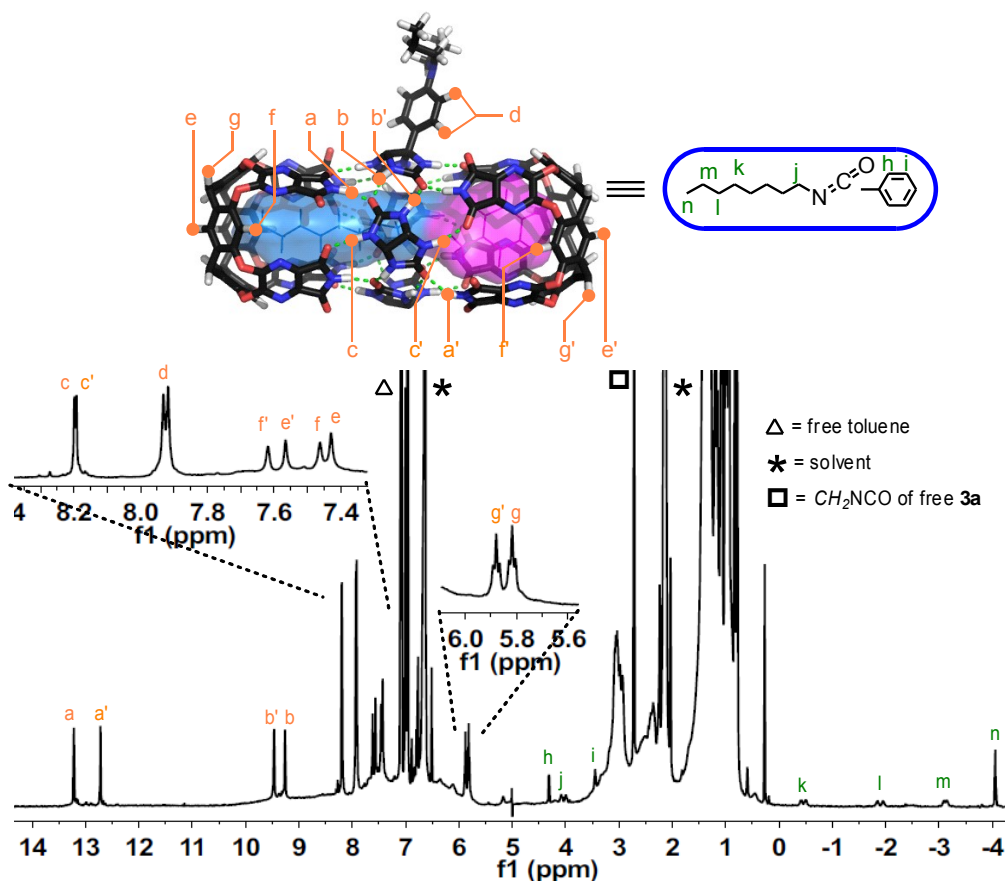


Fig. S-6 ^1H NMR spectrum (600 MHz, 300 K, mesitylene- d_{12}) of **1.2.4.1**⊃(**3a**·toluene).

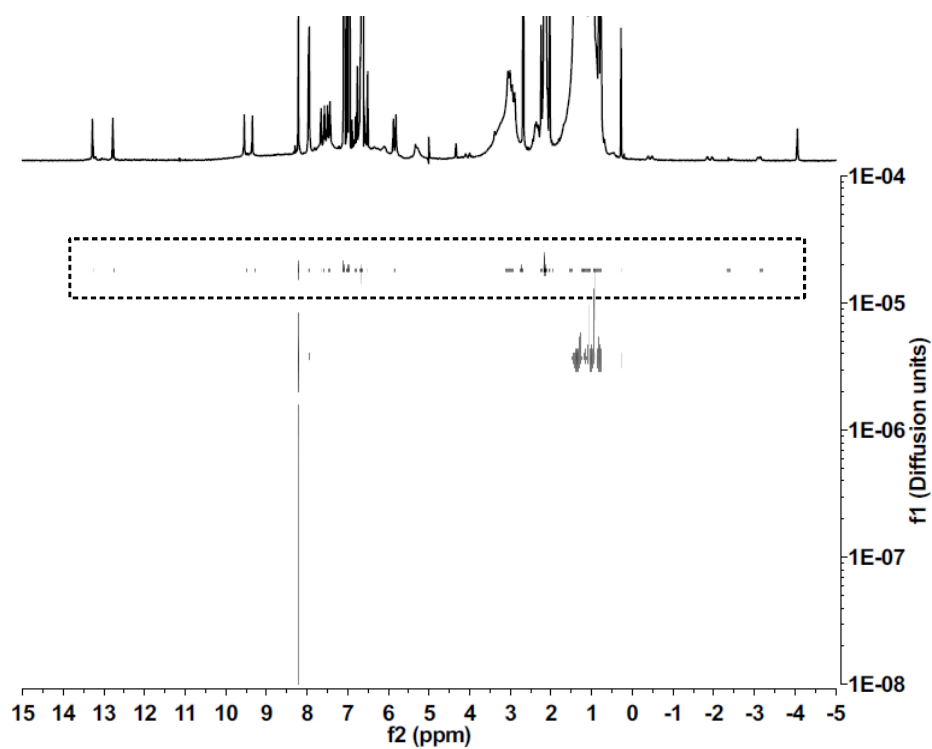


Fig. S-7 ^1H NMR spectra (600 MHz, 300 K, mesitylene- d_{12}) of **1.2.4.1** (3a·toluene).

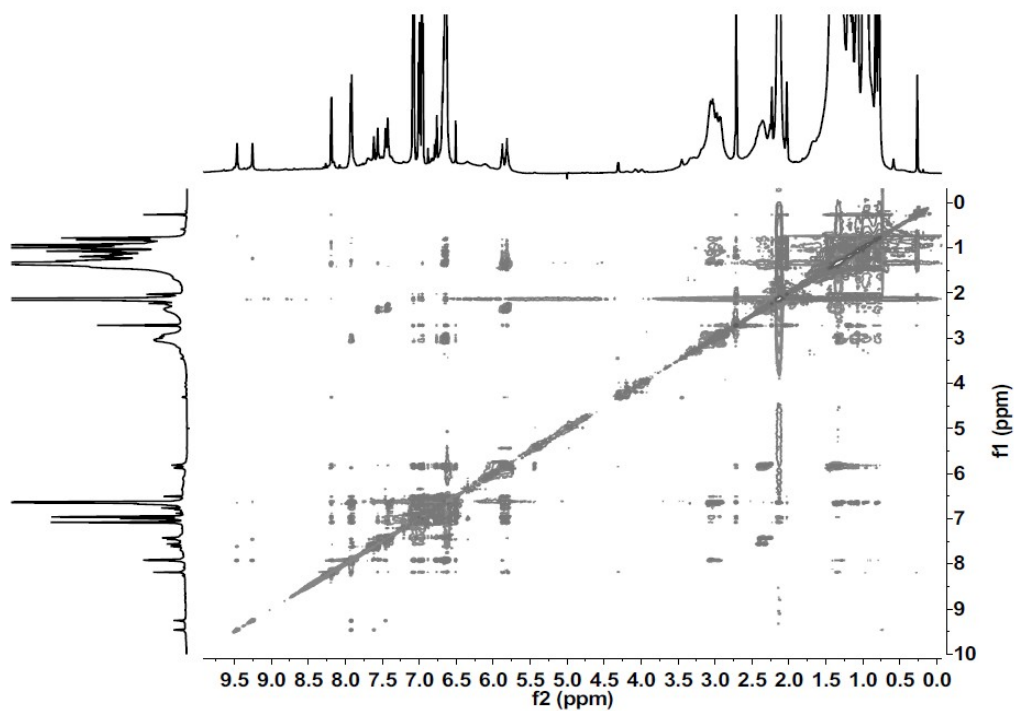


Fig. S-8 2D ROESY NMR spectra (600 MHz, 300 K, mesitylene- d_{12}) of **1.2.4.1** (3a·toluene).

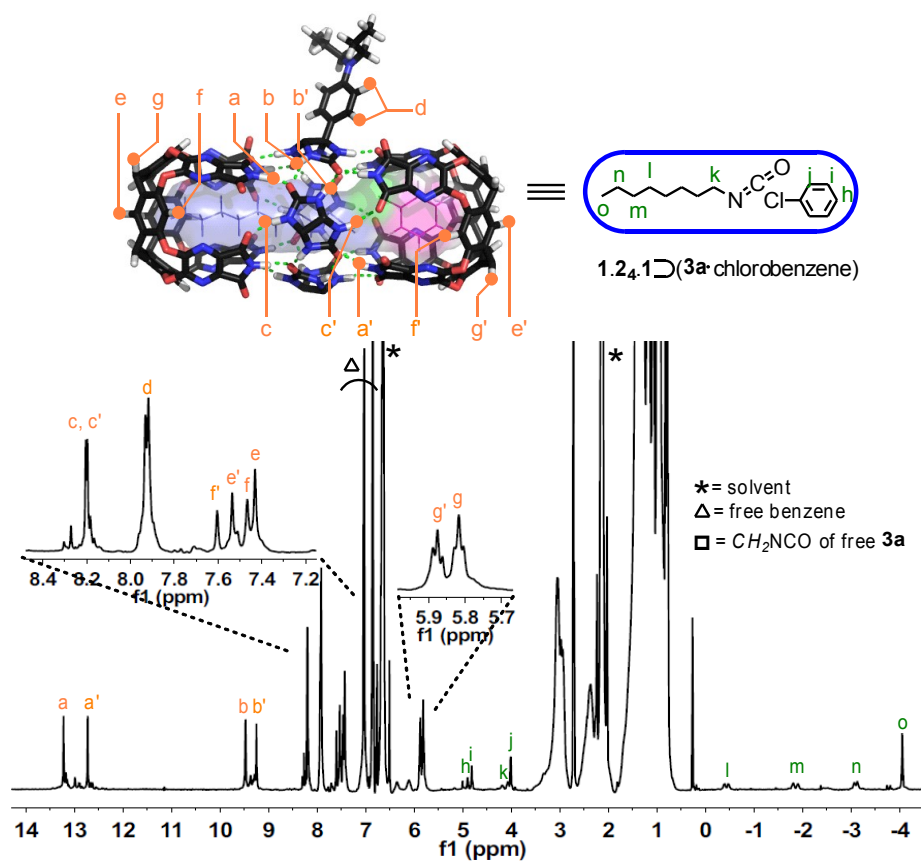


Fig. S-9 ¹H NMR spectrum (600 MHz, 300 K, mesitylene-*d*₁₂) of 1.2.4.1D(3a·chlorobenzene).

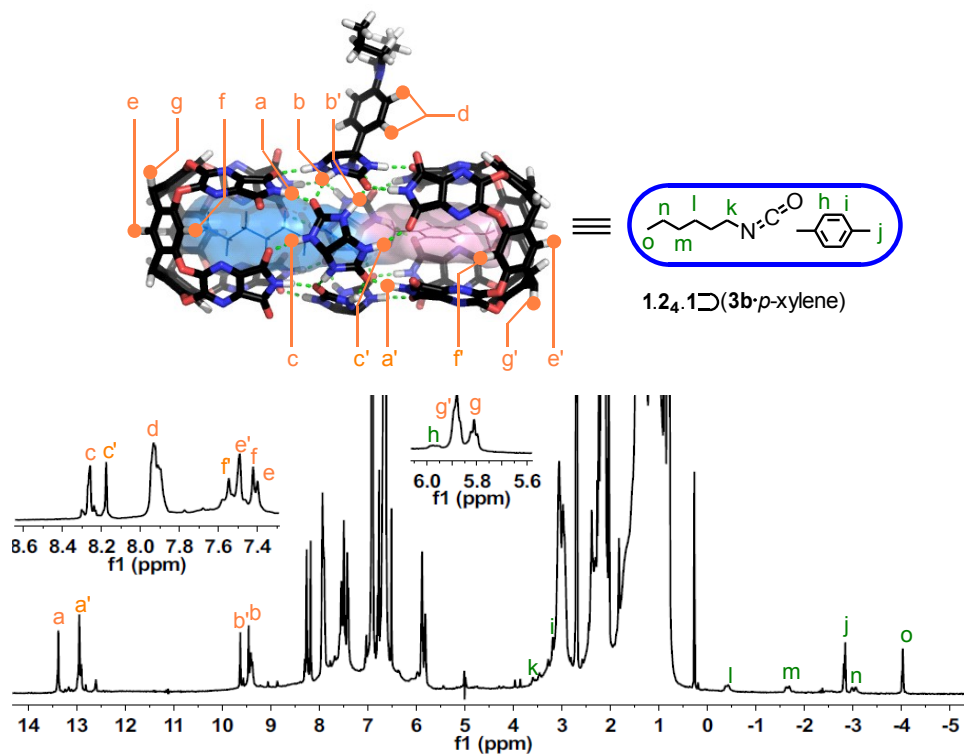


Fig. S-10 ¹H NMR spectrum (600 MHz, 300 K, mesitylene-*d*₁₂) of 1.2.4.1D(3b·*p*-xylene).

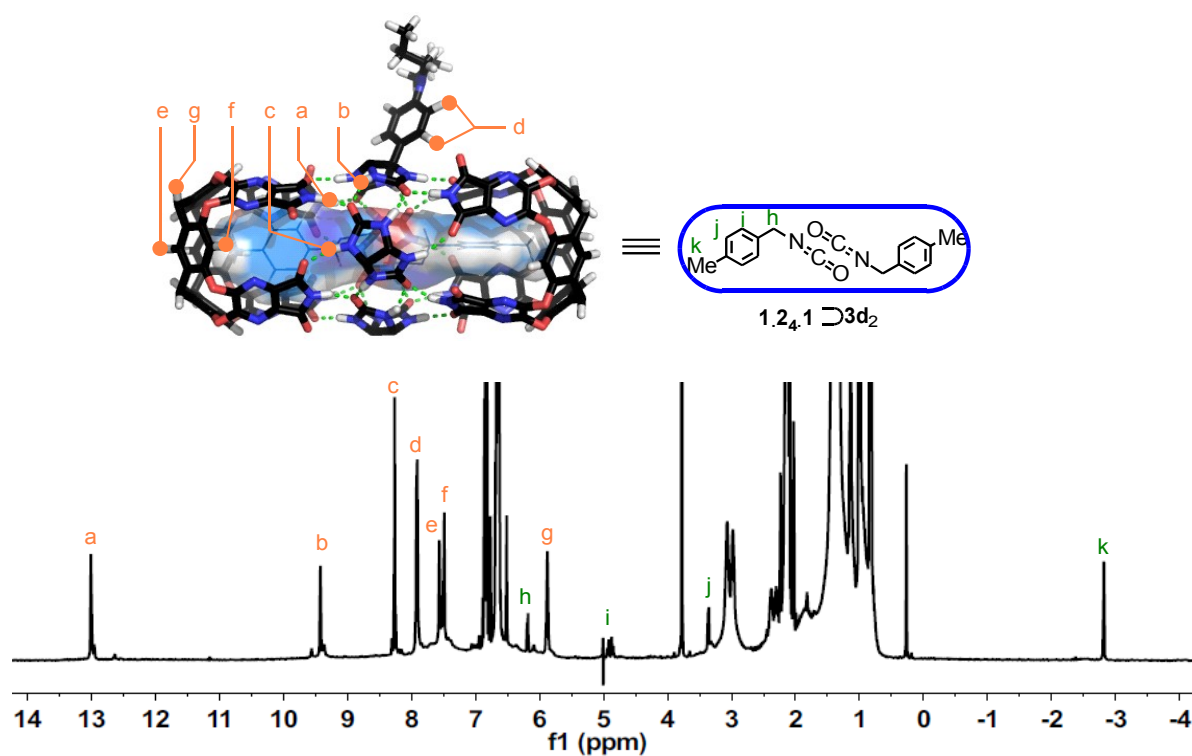


Fig. S-11 ¹H NMR spectrum (600 MHz, 300 K, mesitylene-*d*₁₂) of 1.2.4.1D3d₂.

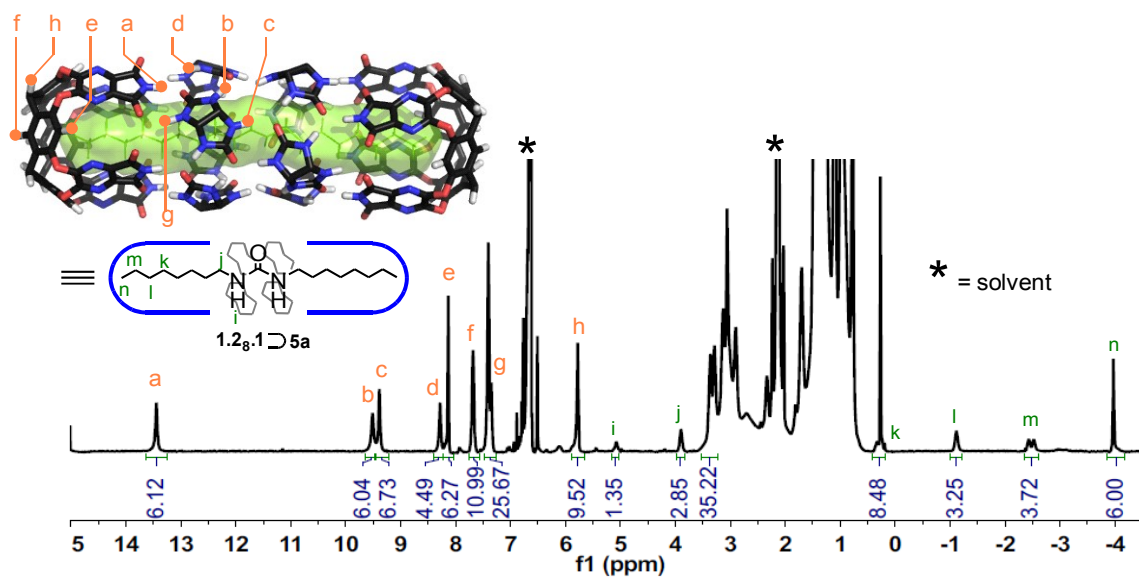


Fig. S12 ¹H NMR spectrum (600 MHz, 300 K, mesitylene-*d*₁₂) of 1.2.8.1D5a.

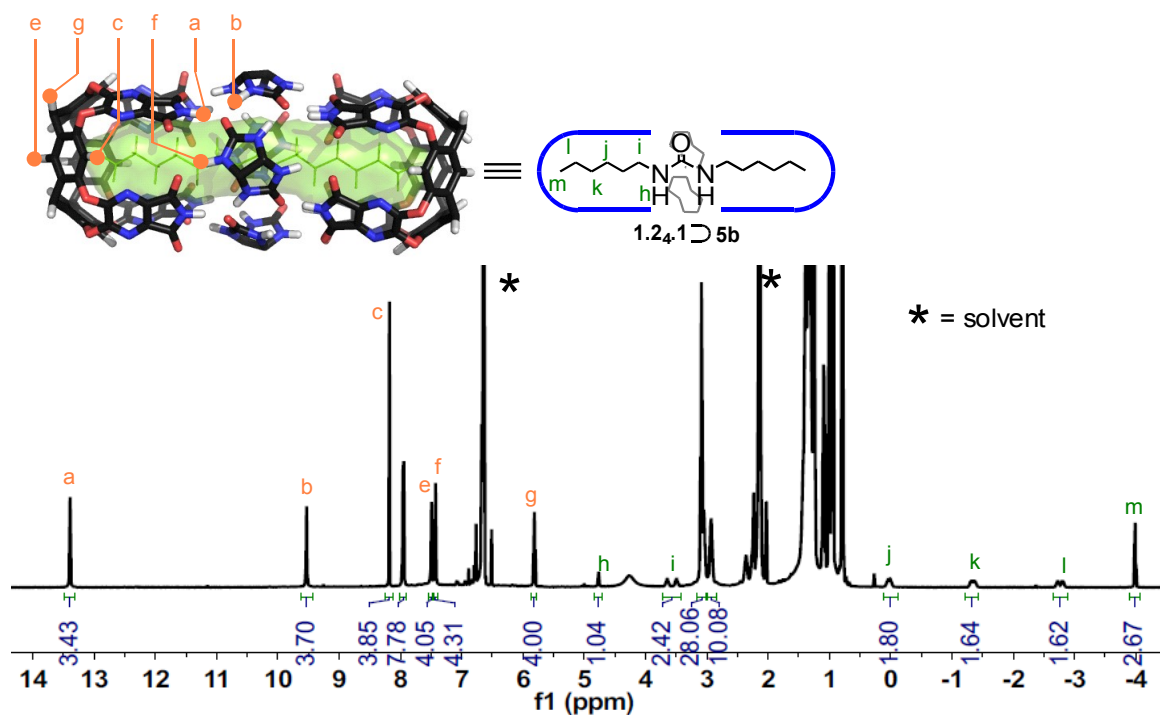
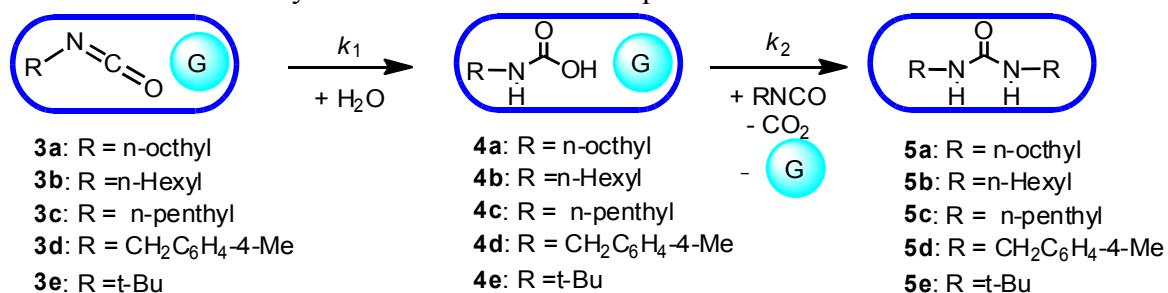


Fig. S-13 ^1H NMR spectrum (600 MHz, 300 K, mesitylene- d_{12}) of **1.2.4.1D5b**.

Kinetic measurement: In a typical experiment, samples were prepared for kinetics measurements as follows. To the suspension of **1** (4 mg, 2.4 mM) and **2** (3 mg, 5.2 mM) in mesitylene- d_{12} (0.5 mL) in an NMR tube, stock solution of isocyanate was added. The mixture was heated for a second and then sonicated for several minutes to give a solution. The spectra were periodically acquired while the sample was kept at room temperature (298 K). The parameters for data acquisition of the kinetic experiments were set as $d_1 = 15$ sec. The concentrations of starting material, intermediate (carbamic acid), and product (N,N' -dialkylurea) were monitored by integration of their peaks of CH_3 protons. Concentrations were tabulated with respect to time. Control experiments were carried out under the same conditions but in the absence of **1**, absence of **2** or absence of **1** and **2**. Simulations were based on a consecutive reaction of two irreversible first-order reactions $\text{A} \rightarrow \text{B} \rightarrow \text{C}$, where A, B and C are starting material, intermediate and product, respectively.

Table S-2. Reaction of isocyanate in self-assembled capsule.



Entry	isocyanate	G	Host	PC (%)	conv. ^b (%)	k_1 (x 10 ⁻⁷ s ⁻¹)	k_2 (x 10 ⁻⁷ s ⁻¹)
1	3a	C ₆ H ₆	1.2.4.1	47	31	1.2	2.2
2	3a	C ₆ H ₅ Me	1.2.4.1	50	78	4.0	3.0
3	3a	C ₆ H ₅ Cl	1.2.4.1	49	90	8.5	6.5
5	3b	<i>p</i> -xylene	1.2.4.1	47	100	5.0 ^c	0.0
6	3c	–	1.2.4.1	–	0	–	–
7	3d	3d	1.2.4.1	53	0	–	–
8	3e	3e	1.1	53	0	–	–

^a In mesitylene-*d*₁₂ at 294 K. ^b conversions (conv.) were determined by ¹H NMR spectroscopy. ^c k_1 was obtained as initial rate constant.

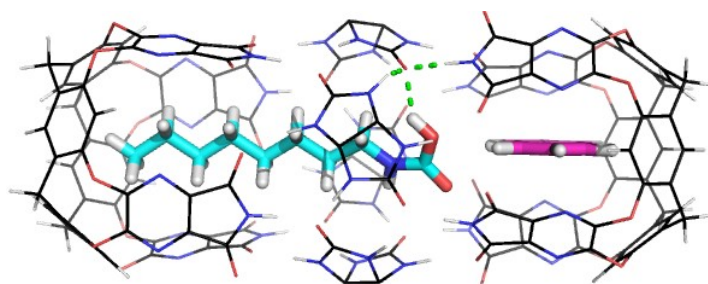


Fig. S-14 Energy-minimized structures (Spartan, PM3) of **1.2.4.1**⊃(**4a**·benzene). The molecular modeling suggests the **4a** can be stabilized by hydrogen bonding interactions between **4a** and host framework.

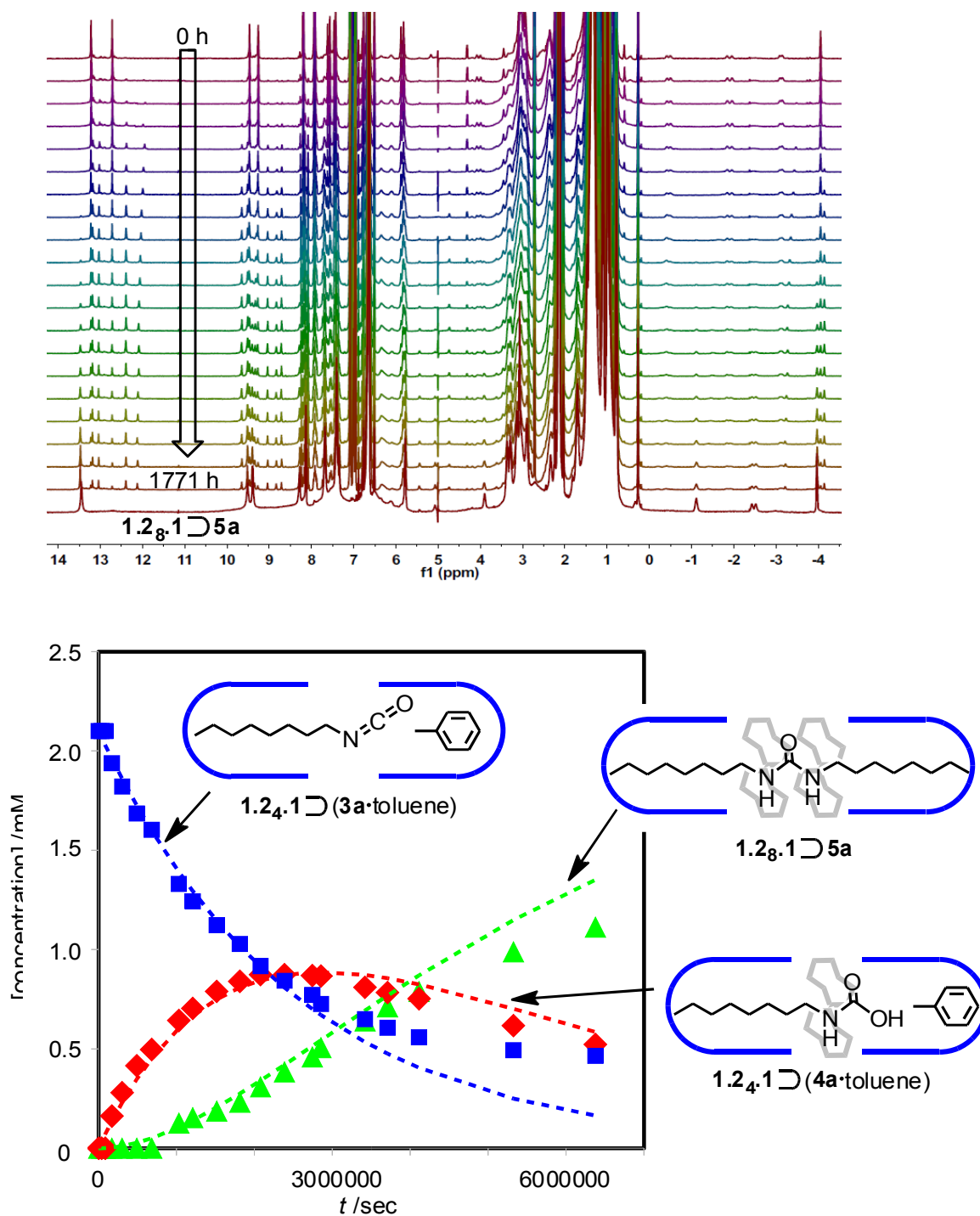


Fig. S-15 Reaction profile of 1.2.4.1 (3a·toluene). The curves calculated by assuming consecutive and nonlinear fitting using integrations of CH₃ proton of each components.

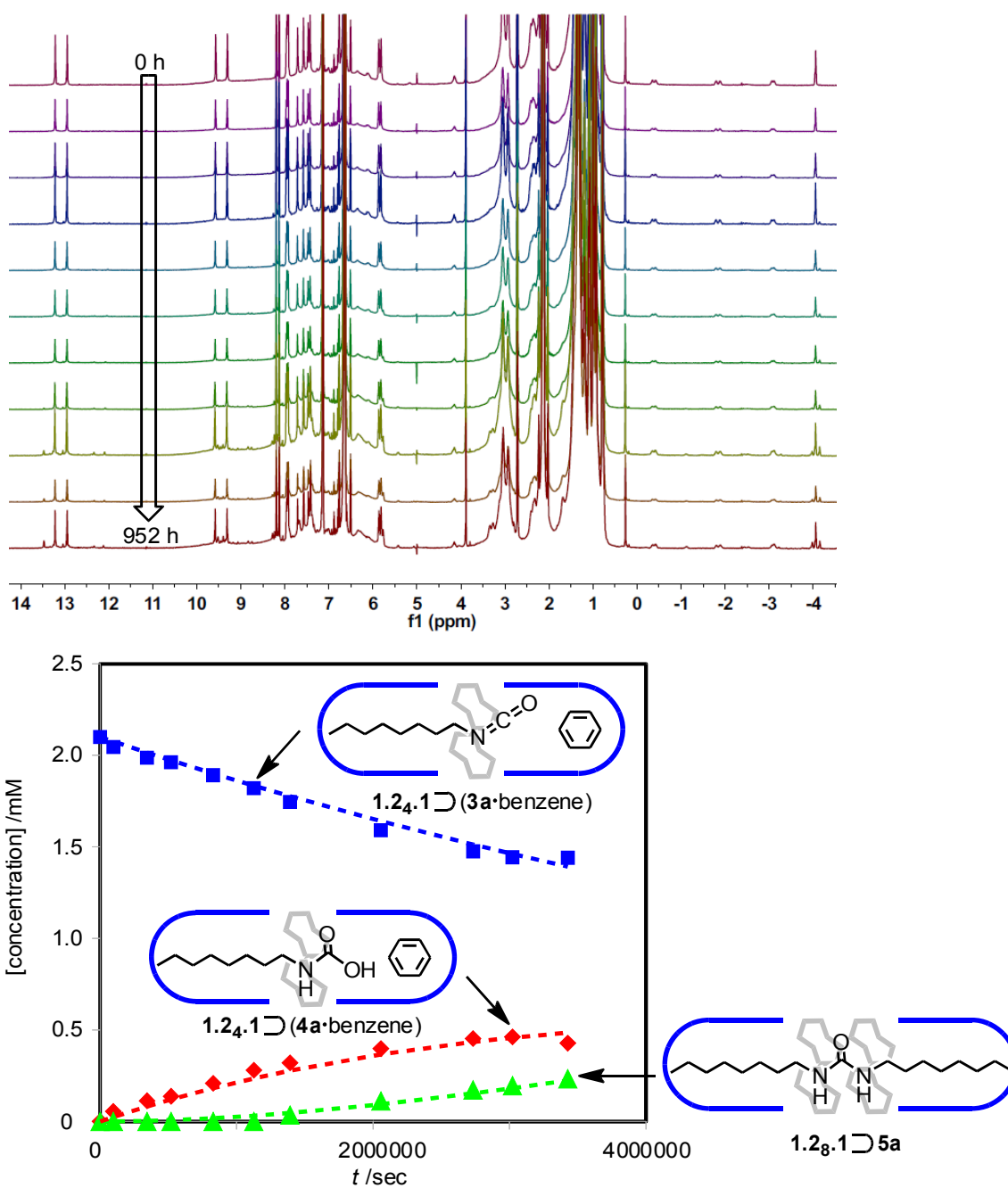


Fig. S-16 Reaction profile of 1.2.4.1(3a·benzene). The curves calculated by assuming consecutive and nonlinear fitting using integrations of CH₃ proton of each components.

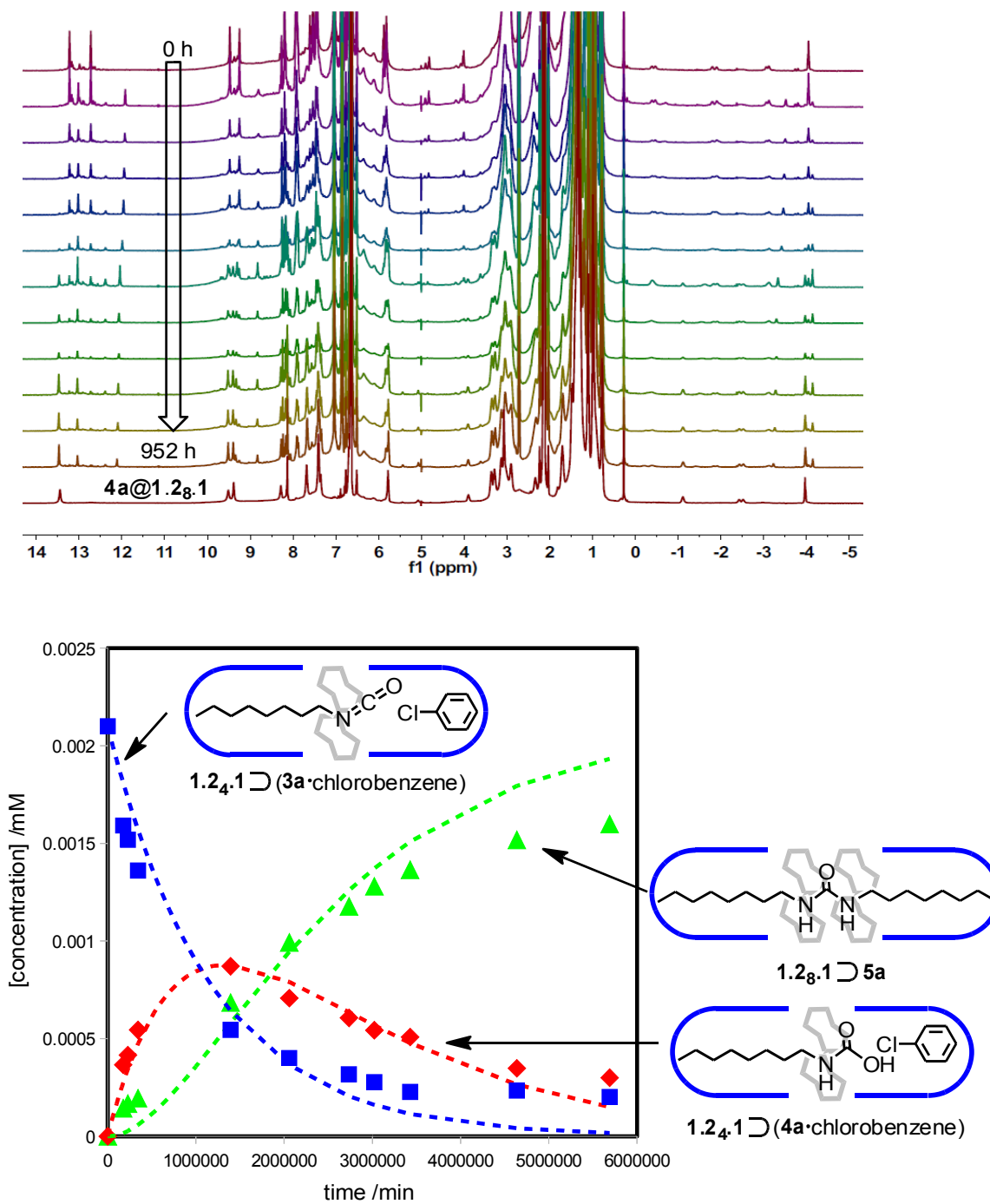


Fig. S-17 Reaction profile of 1.2.4.1⊃(3a-chlorobenzene). The curves calculated by assuming consecutive and nonlinear fitting using integrations of CH₃ proton of each components.

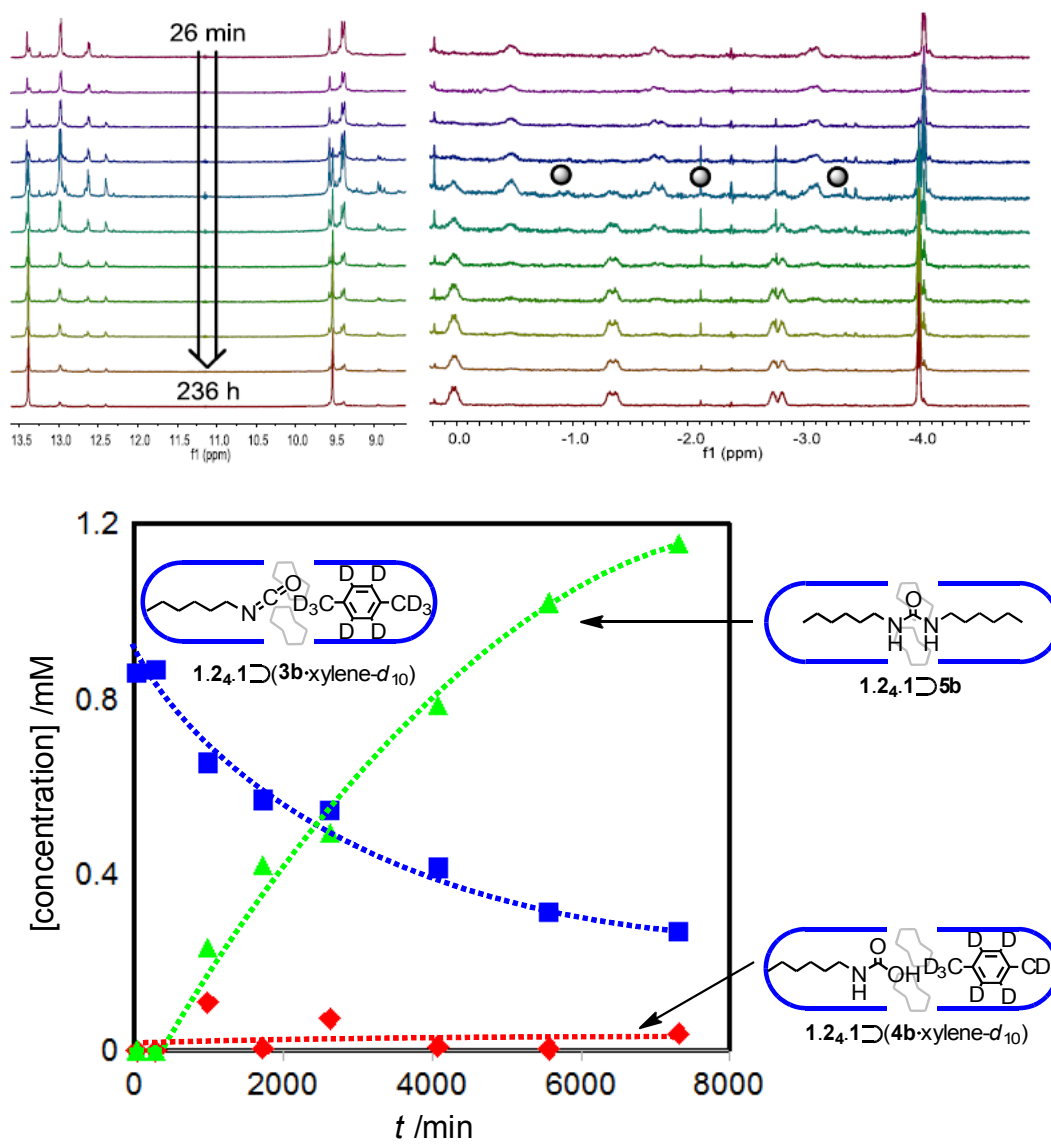


Fig. S-18 Reaction profile of 1.2.4.1D(3b-xylene-*d*₁₀). The curves calculated by assuming consecutive and nonlinear fitting using integrations of CH₃ proton of each components.

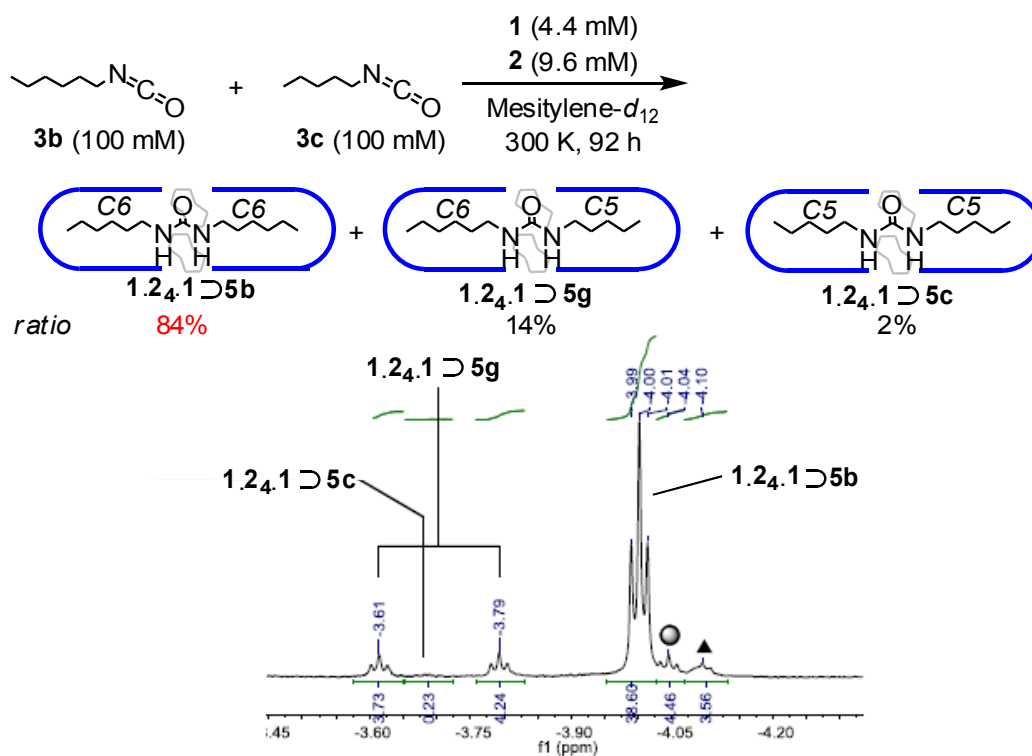
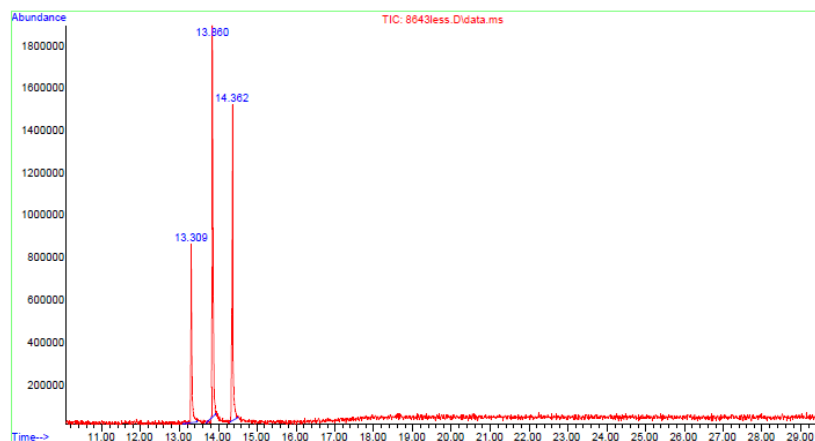


Fig. S-19 Competition experiment of a reaction of **3b** and **3c** in the presence of **1.2,4.1**. Circle, **1.2,4.1** \supset (**3b**·xylene- d_{10}); triangle, the reaction intermediate **1.2,4.1** \supset (**4b**·xylene- d_{10}).

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2	13.860	BV	0.042	34182573	13.693	13.938
3	14.362	BV	0.038	22419890	14.303	14.499

Fig. S-20 Competition experiment of the reaction of **3b** with **3c** in DMSO- d_6 .